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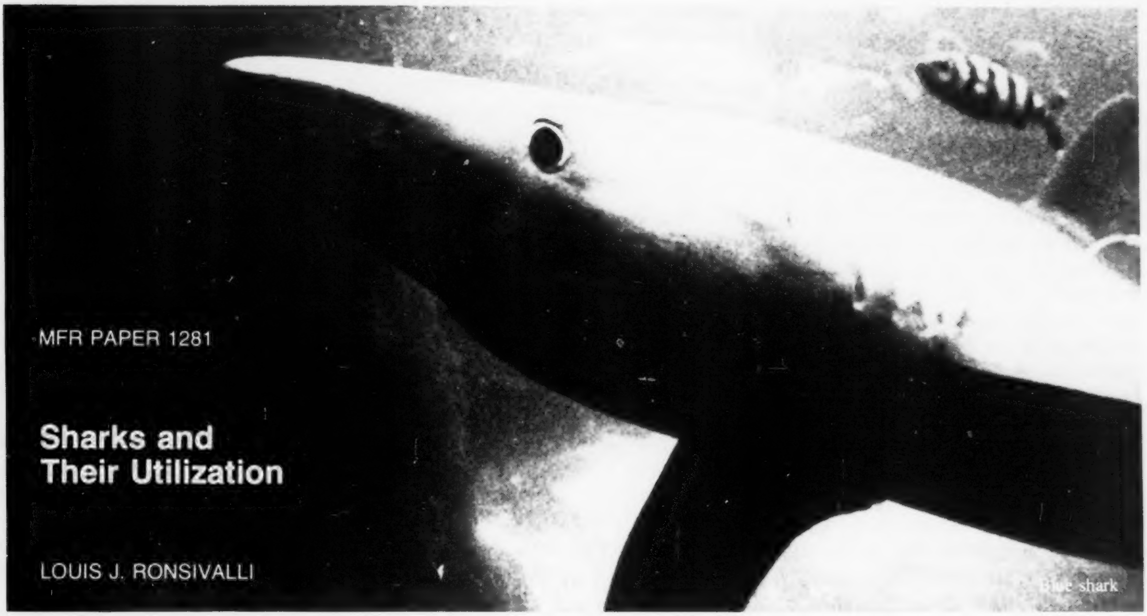

Blue shark

MFR PAPER 1281

# Sharks and Their Utilization

LOUIS J. RONSIVALLI

## INTRODUCTION

Of all the creatures in the sea, sharks are the most feared by man. Why shouldn't they be? Some of the large sharks can snap off a man's leg with their powerful jaws—jaws that can exert biting pressures as high as 40,000 pounds per square inch (2,812 kg/cm$^2$). Accounts of the slaughter, by sharks, of hundreds of people who abandoned sinking ships at sea leave no question as to the shark danger to man. However, one must be reminded constantly that the image denoted by the word "shark" is always that of the potentially dangerous species like the white, blue, mako, tiger, and others and that the notoriety gained by these species is unconsciously attributed to all sharks. Actually, there are many more shark species that are not dangerous to man, and most of these are too small to cause serious injury to a person.

Sharks are a nuisance to fishermen because they can wreck fishing gear with their sharp teeth and sharp denticular scales and because they devour the trapped fish. (To run one's hand across the denticular formation of a shark is like running it across the teeth of a freshly sharpened saw.) On the other hand, sharks represent a source of food, pharmaceuticals, and other useful materials for man, as we shall see later.

Much has been written about sharks, and two notions eventually become evident to the reader: 1) If anything can be said for certain about the behavior of sharks, it is that one cannot be too certain about it—they can be completely unpredictable; and 2) if anyone allows himself to get too confident about what to expect from the different species of sharks and tends to get careless in the presence of certain species in particular, he is apt to get an accelerated education about shark behavior, which unfortunately may last him only for a very short time.

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## DESCRIPTION AND PHYSICAL CHARACTERISTICS OF SHARKS

In the scheme of biological classification, the sharks (of which there are about 300 species) belong to the order Selachii—Phylum: Vertebrata, Subphylum: Pisces, Class: Chondrichthyes, Subclass: Elasmobranchii, Order: Selachii.

Sharks are vertebrates with well developed lower jaws and bony teeth. They have two pairs of appendages supported by the pectoral and pelvic girdles and a cartilaginous skeleton. They have no true bones; however, parts of the skeleton may be stiffened by mineral deposits (e.g., calcium fluorophosphate), such as in the spinal column, resulting in a structure that resembles bone so closely that the distinguishing characteristics can only be identified by microscopic examination. Scales are denticular (toothlike) in structure in that they include the mesoderm[1] as well as the ectoderm[2] in their composition. Sharks have two nostrils, a sympathetic nervous system, a multiple-valve heart, a pancreas, and a spleen, but they lack a swim bladder.

Sharks have 5-7 pairs of gills (most have 5 pairs) that are located laterally or

[1]Mesoderm—the middle layer. In the case of teeth, it is the dentine.

[2]Ectoderm—the outer layer. In the case of teeth, it is the enamel.

nearly laterally, and they have movable eyelids. The dorsal and pectoral fins are rigid, and the anterior edges of the latter are not attached to the head. A few genera are luminescent (e.g., *Isistius*) but the majority are not.

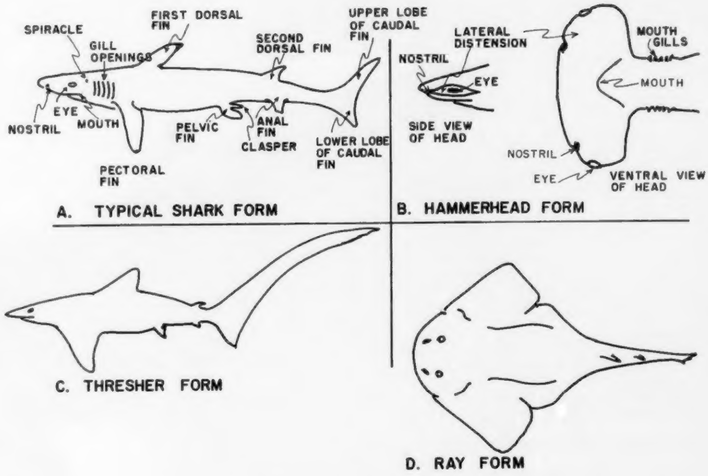



Figure 1.—Outlines of different forms of sharks.

The body fluids of marine teleosts (bony fishes) are less salty than seawater, and since they lose water to the sea through the process of osmosis, it is necessary for them to continually drink seawater and to dispose of the excess salts. On the other hand, the fluids of freshwater teleosts are more salty than the water around them, and they absorb water through osmosis constantly. Thus, freshwater fish do not need to drink water. Sharks contain large amounts of urea which, together with trimethylamine oxide, contribute to a salt concentration in their body fluids which is greater than that in the sea around them. So, as with the freshwater teleost fishes, sharks do not have to drink water since they too obtain water from their surroundings through osmosis.

Sharks are known to exist in a state of commensalism with pilotfish. (Commensalism exists between two organisms when one benefits from the other while the other neither benefits nor suffers from the relationship.) Pilotfish about 2 feet (about 0.6 m) in length, are the beneficiaries in this case as they find a measure of protection by the mere fact that they are near the shark, and they eat from the same prey as does their host. Apparently the pilotfish are skillful enough to avoid the shark's mouth. A symbiotic relationship exists between sharks and the remoras, a class of small fish also about 2 feet (about 0.6 m) in length. (Symbiosis exists between two organisms when each benefits from the other.) In this case, the remora fastens itself to the shark by means of a suction cup and feasts on shark prey, and the shark benefits from the fact that the remora eats parasites on its body.

### Shapes

The shapes of sharks vary from that of the streamlined mackerel shark to that of the angel shark which is flat and broad, resembling a ray. Four markedly different outlines are illustrated in Figure 1, with outline A labeled so as to provide information on some of the external gross anatomy of sharks in general. There is no known explanation for the development of the unusual lateral distensions of the head of the "hammerhead sharks," many of which are dangerous to man, and some hammerheads are large enough and aggressive enough to butt and capsize small boats from which they have been harpooned or speared. The eyes of hammerhead sharks are at the ends of the distensions (see Fig. 1) and the nostrils are generally at the outer forecorners. The thresher form (Fig. 1C) shows the extreme enlargement of the upper lobe of the caudal fin. The pectoral fins are also enlarged. Other sharks have intermediate enlargements of these parts. The shape of the angel shark (Fig. 1D) illustrates the ray-like form of some sharks.

### Size and Growth

Shark sizes vary widely. The largest shark, *Rhincodon typus,* commonly called the whale shark, is reported to reach lengths of about 50 feet (about 15 m). The smallest shark, *Squaliolus* can be smaller than 0.5 foot (about 15 cm). In general, adult female sharks are 5 percent longer and 25 percent heavier than adult male sharks. Sharks grow slowly, which suggests that they live a relatively long life. Not enough information has been accumulated to give more details, but in one experiment only a few to 20 inches (51 cm) of growth was noted during a period of 7 years.

### Mobility

The mobility of sharks is quite variable. The mackerel sharks, Lamnidae, are fast swimmers, reaching speeds of 40 miles (about 64 km) per hour in short bursts, whereas the Greenland Shark, *Somniosus,* is sluggish and relatively slow. The mako shark, a member of the Lamnidae, is not only a fast, powerful swimmer, but it can leap out of the water covering respectable distances at a leap. Other sharks, including the thresher shark and even the more sluggish basking shark, are capable of leaping out of the water, but the mako shark is a more outstanding and a more spectacular leaper, especially when caught on a fisherman's hook. The only maneuver that a shark is unable to do well is to stop quickly. The reason for this is that its pectoral fins are designed more rigidly than in other fish. The fixed position of the fins is to provide lift while the sharks are in forward motion, much as the flaps on the wings of aircraft provide lift. (In other fish the pectoral fins are movable, and they can be

turned to provide a stopping action.) It has been speculated that the unusual head form of the hammerhead sharks acts as a rudder, permitting greater maneuverability.

### Body Temperature

Nearly all of the members of Lamnidae maintain body temperatures above that of their environment. Other sharks have body temperatures at or near the temperature of their environment. Pertinent to this situation, it has been shown that the contraction and relaxation of muscle occurs faster as the temperature of the muscle is increased (within limits). Experimental data show that when a muscle is allowed to act for a given period of time at two temperatures that are 18°F (10°C) apart, its activity at the higher temperature is about three times as rapid as its activity at the lower temperature for any given unit of energy supplied to the muscle. However, to maintain warm body temperatures in the cold aquatic environment where heat transfer out of the body could be significant, the body must have an extraordinary ability to retard heat loss. The anatomy of the shark includes the rete mirabile, a network of blood vessels that takes advantage of the principle of counter-current heat exchange which performs this conservation function. In general, sharks can tolerate a wider range of water temperatures than can many of the bony fishes, and this advantage would appear to be related to their ability to control their body temperature.

### Relationship Among Body Density, Oxygen Requirement, and Sleep

As sharks have no swim bladder, they cannot decrease their density (which is greater than that of water). Therefore, they must swim constantly to keep from sinking. Their continuous swimming is also necessary, for some sharks, because it is the only way that a constant stream of water can be made to pass through their gills. This is vital to their survival, because they must have the oxygen that is dissolved in the water, and to maintain a sufficient supply of oxygen they must replace the water in their gills continually. Some sharks have spiracles (a hole behind each eye) through which water can enter and pass directly over the gills. These sharks must still swim to keep from sinking, but they can stop and rest on shallow bottoms if they wish since their oxygen supply is not dependent on their motion. Sharks without spiracles are believed to have to swim continuously from birth to death. There are a few reports which indicate that some sharks sleep, but during such periods they are able to pump water through the gills by an apparent automatic mechanism that coincides with sleep.

### Sensitivity

Sharks appear to have a low intelligence and to be insensitive to pain. Especially in "frenzied" attacks, they continue their assaults even though retaliatory action is highly injurious or lethal, or even though their attacks bring them in contact with sharp or otherwise injurious materials. Sharks have a keen sense of smell, permitting them to detect substances as dilute as one part per billion. Thus, their olfactory sense, which allows them to detect prey up to several hundred yards away, is a major component of their hunting ability, and at least one genus, *Mustelus,* hunts chiefly by smell.

Sharks have sharp eyes that they can focus and adjust according to available light. There is no evidence to show that sharks can distinguish among colors although they may be attracted to the lighter ones. At close range, eyesight is the most effective sense. While it is generally accepted that their sense of smell is the principal sense that leads sharks to food, a study supported by both the National Science Foundation and the Office of Naval Research (Anonymous, 1964) resulted in convincing evidence that sharks are invariably attracted to the prey by low frequency sounds—7.5 to 100 Hertz (cycles per second)—at distances over 200 yards (about 183 m).

The sounds were made in the absence of any possibility that the sharks could either see or smell the source of the sounds. The sound pulses were varied, allowing two observations: 1) That sharks responded only to low frequency sounds when they were made in bursts. When sound signals were continuous the sharks were not attracted. Prior data showed that struggling and crippled fish emitted low frequency sounds in bursts; therefore it was concluded that sharks are attracted to intermittent bursts of low frequency sounds because they believe these to be the signals to the presence of easy prey. 2) Other fish, such as barracuda, were also attracted to the sounds.

It is believed that the lateral line of sharks is instrumental in their ability to detect a variety of water movements such as might be created by the nearby activities of other marine life. The range of detection does not exceed several hundred feet (1 foot = ca. 0.3 m).

Tiny sensors called pit organs, scattered over the entire surface of the shark, are said to detect changes in salinity and these appear to play a role in regulating the activities of sharks in and near brackish waters. They have small cup-like nerve sensors (called ampullae of Lorenzini) on their noses and along their lateral lines which are reported to be able to detect temperature changes in the water. But more important, it has been determined by experiments that these organs permit sharks to detect other fish through the electric potentials they emit. The ampullae, whose role is not completely understood, exist as subcutaneous nerve centers connected to tiny openings in the surface by canal-like structures containing a gel of low electrical resistance. Supporting evidence for the electrical receptor property of the shark was obtained in experiments in which sharks were able to locate prey which was adequately protected against visual, auditory, and olfactory detection but was not shielded against electrical transmissions. When hidden electrodes were used instead of prey to emit a similar electrical potential, the test sharks attacked the electrodes (apparently convinced that they were attacking a concealed prey). A measure of the sensitivity of these electroreceptors showed that a shark can detect an electrical field of 0.01 microvolt per centimeter (1 centimeter = 0.394 inch). The detection of variations

in electric signals among other fishes is promoting speculation among scientists that electroreceptors in fish may be involved in intentional as well as unintentional communications.

## Reproduction

Reproduction in sharks involves internal fertilization. The male shark has a pair of grooved copulatory organs called "claspers" that develop as penis-like appendages of the pelvic fin (see Fig. 1A). While the claspers are normally relaxed, they swell and become erect just prior to mating. The erect claspers are inserted into the two sexual orifices in the cloaca of the female. (Often only one clasper is used.) The sperm is guided in by the groove of the clasper(s).

Shark copulation is not simple. The male shark is, as stated above, generally smaller than the female, and he might in some cases end up as food for the female instead of her suitor. At any rate, the male does not have an easy time of it, even though he is equipped with clasper hooks and an array of spurs and spines, in addition to his teeth, that enable him to grab the female and cling to her and then to work himself into position to fertilize her.

In the larger species, the male has an even more difficult time and might not succeed without cooperation from the female. Cooperation may be induced by slashes to the body of the female inflicted by the male. It is during this critical part of the courtship that the female may respond by devouring the male instead of cooperating with him and that the hide of the female is sufficiently damaged as to lower its value for the production of shark leather. Even though the courtship of sharks is obviously dangerous, the propagation of sharks over the many eons of their existence implies that sufficient successful courtships occur.

Sharks vary in their form at birth, and there are three general categories. Oviparous sharks, which include the horn sharks, the cat sharks, and the whale sharks, lay eggs having a tough, leather-like covering and leave them to hatch. Viviparous sharks, which include the hammerhead species, hatch their eggs internally, and, much like mammals, deliver fully formed active pups with placentae. Most sharks, however, are ovoviviparous. In this case the eggs are also hatched internally and the young are fully formed and active, but there is no placental connection between embryos and mother.

Generally the number of offspring produced by sharks and other cartilaginous fishes is relatively small (a few dozen at most) when compared with the number of eggs produced by the bony fishes (up to a few million). However, sharks have a high survival rate since they are born either fully formed and able to fend for themselves, or as eggs they are protected by a tough casing. The survival rate of the offspring of the bony fishes, on the other hand, is very low, since there is a high degree of susceptibility to predation during their early stages of development when they are of relatively tiny size and practically defenseless. Also, because fertilization of cartilaginous fishes is done internally, the probability of fertilizing the eggs is much greater than in the bony fishes where fertilization occurs externally. Generally pups are born in spring to early summer either annually or biennially (depending on the species). The young remain in a nursery area, usually in shallow water, which the adult males do not enter. The adult females leave the nursery area quite soon. Fortunately, the females are not inclined to feed while they are in the nursery area for reason or reasons thus far unexplained; otherwise they might devour the young.

## Feeding

Most sharks are carnivorous. Their teeth are razor sharp and numerous, and their jaws are powerful. Some have crushing teeth that enable them to feed on hard-shelled mollusks and crustaceans. The majority of sharks feed on whatever they can get such as small fish, including smaller sharks, squid, and pelagic crustacea. Ironically, the largest species, whale sharks, feeds on minute plankton forms and on small schooling fishes. Sharks have been found to avoid decaying shark flesh. It was once considered that decaying shark might be a good repellent, and further work resulted in the development of "Shark Chaser," which is described later.

Shark teeth are not set rigidly in the jaws and some are lost from time to time, especially when sharks go into a violent attack pattern in which they tear at steel cables and other hard, tough objects. However, lost teeth are replaced when a row of new teeth from the many rows of replacement teeth with which sharks are endowed takes the place of the old row of teeth. This complete change of teeth occurs quite often—as often as every 2 weeks. Thus, sharks are never without teeth throughout their lives.

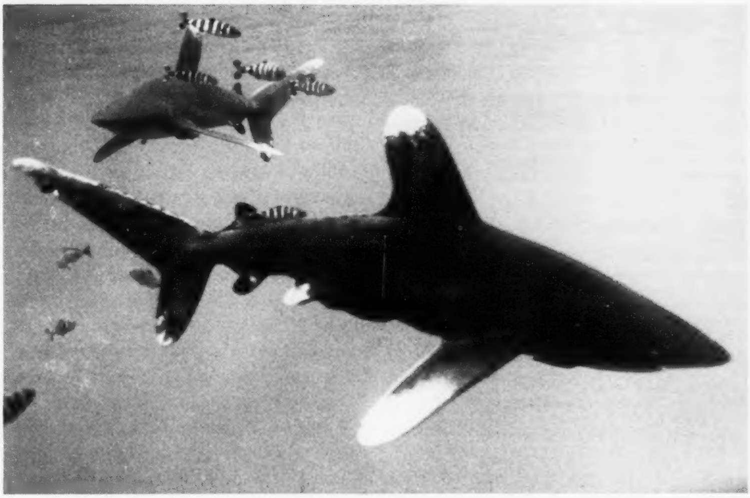
The number, size, shape, and set of shark's teeth vary among the different species. One peculiarity reported is that some sharks have protrusible teeth. When a shark having this characteristic opens its mouth to bite, the teeth tilt outward, thus making possible a bite covering a large area and permitting the shark to bite into nearly flat surfaces. As the jaws close to complete the bite, the teeth start to tilt inward, insuring a firm grip on the bite that is being taken.

As the predator of any shark is often a larger shark, it is not unusual to find a hooked shark on a line that has swallowed a smaller shark that was originally hooked to the line or to find a hooked large shark that, in its handicapped position, is ravaged by adjacent sharks. In a feeding frenzy involving large numbers of sharks, some of the feeding sharks are devoured by others. If one species of shark is the dominant predator of the other sharks, it appears that the hammerhead species is in a superior position, and although the reason is not known, it seems to be related to the unique head form (see Fig. 1B).

The feeding of sharks is observed to follow a unique general behavior. It generally starts slowly and gathers momentum, especially as the number of sharks involved increases. Whether hunger is the trigger that starts sharks feeding is not known since they may begin to feed on a full stomach in some cases, and in some cases (males during mating season) will not feed even

though they may exhaust nearly all of their liver-stored fats. Some evidence has been obtained which suggests that sharks can detect uneasiness and fear and maybe an odor that emanates as a specific consequence of fear or panic in their prey which motivate them to attack.

Evidently the shark needs to employ most or all of its senses to ascertain the suitability of foods, but sometimes it swallows objects such as bottles, cans, and other debris indicating that it did not wait for proper identification of the food. While indigestible debris often enters the stomach of the shark, it is reportedly easily regurgitated when its accumulation becomes objectionable. There are numerous stories about the odd indigestible items found in the stomachs of sharks, but one of the strangest is a centuries-old account of finding a man encased in armor in a 22-foot shark caught off France.



Whitetipped sharks and pilotfish. (Photo by Reginald M. Gooding.)

## OCCURRENCE AND HABITS

Sharks are mainly marine species occurring nearly worldwide, but some species enter brackish waters and even the fresh waters of large rivers. The intrusion of sharks into rivers is not too uncommon; sometimes they swim into the upper reaches of the rivers, and at least one species, *Carcharinus leucas,* otherwise known as the bull shark, is found in Lake Nicaragua, Nicaragua. This lake, over 100 miles long (about 160 km) and nearly 50 miles wide (about 80 km), empties into the Caribbean Sea about 100 miles away (about 160 km) via the Rio San Juan. There has been, and still is, much speculation and controversy as to whether or not the lake shark commutes to the sea. Even though the river has many rapids, it is believed that the sharks which have been seen in the river can easily swim from the sea to the lake. Also, evidence from the gut contents of lake sharks points to excursions by lake sharks to the sea. Pilotfish and remoras that may accompany a shark to a river must abandon their host or perish as neither of these fish can survive in rivers.

Sharks are found in all of the oceans, but the great majority inhabit the tropical and subtropical belts. Only one genus, *Somniosus,* is found in polar seas. Sharks are known to roam the high seas, and some will follow ships to feed in disposed garbage or other marine creatures that might be attracted to the ship's effluents. Most sharks inhabit relatively shallow water; however at least one species, *Centroscymnus coelolepis,* has been reported to go to depths of 1,500 fathoms (9,000 feet or 2,745 m).

Migrating adults usually, but not always, segregate by sex with males favoring cooler, deeper water than the females, but they nearly always segregate by size, except in rare cases. Migrations of sharks seem to be influenced by seasonal temperature changes in the water, but there is some evidence to show that female sharks migrate to specific environments to lay eggs or to give birth to their young. Whether sharks migrate to special mating grounds is not known although this appears to be the case.

The movement of sharks can be determined by a tagging method. To date, more than 10,000 sharks have been tagged by federal scientists and others. The maximum recorded distance to have been traveled by a shark between the point it was tagged (in New England) and the point it was caught (in South America) is 2,070 miles (about 3,330 km). The maximum time elapsed for any tagged shark between the time it was tagged and the time it was recaptured is 7.5 years. The tagging experiments have resulted in the following conclusions:

1. Blue sharks can travel to locations at least 1,000 miles (1,609 km) from any given point within 1 year.
2. Blue sharks and mako sharks follow common migratory routes that are also followed by white marlin and perhaps swordfish.
3. Migratory routes followed by sharks may depend on their size.
4. The growth rate of sharks is slow.

More data on movements as well as on longevity, growth rates, and other important characteristics of sharks are certain to be produced as a result of the tagging experiments now underway.

## RELATIONSHIP TO MAN

The objectives in scientific research, especially applied research, are usually relatively important and imply a useful potential for man. Sharks, the object of much applied research, have been studied for their potential as food for man, for their possible nonfood value, for their reputation for attacking man, for the heavy damage they impose on fishing gear, and for their unusual physiological and anatomical characteristics. Some sharks are held in captivity in a number of aquaria throughout

**Table 1.—United States facilities reportedly holding sharks in captivity.**

| Facility | Location |
|---|---|
| Cape Haze Marine Lab. | Placida, Fla. |
| Fairmont Park Aquarium | Philadelphia, Pa. |
| Gulfarium | Fort Walton, Fla. |
| Hawaii Marine Lab., Univ. Hawaii | Honolulu, Hawaii |
| Municipal Aquarium | Key West, Fla. |
| Marine Arena | Madeira Beach, Fla. |
| Mount Desert Island Bio. Lab. | Salsbury Cove, Maine |
| Marineland of the Pacific | Marineland, Calif. |
| Marine Studios | Marineland, Fla. |
| Miami Seaquarium | Miami, Fla. |
| New England Aquarium | Boston, Mass. |
| New York Aquarium | New York City, N.Y. |
| Ocean Aquarium | Hermosa Beach, Calif. |
| Shedd Aquarium | Chicago, Ill. |
| Steinhart Aquarium | San Francisco, Calif. |
| Theater of the Sea | Islamorada, Fla. |
| Vaughn Aquarium, Scripps Institute of Oceanography | La Jolla, Calif. |
| Waikiki Aquarium | Honolulu, Hawaii |
| Woods Hole Aquarium | Woods Hole, Mass. |

the country (Table 1) and considerable information has been gained by observing captive sharks. Scientific study of sharks, however, is carried out in only a few of the facilities listed. Table 2 lists some of the more common sharks and how they relate to man.

Because of the strength and ferocity of sharks, they are among the marine species sought by anglers. The shark species recognized as game for sport fishermen and which are recognized by and listed in the records of the International Game Fish Association are: Blue shark, mako shark, porbeagle, thresher shark, tiger shark, and white shark.

World shark landings are reported to be about 400,000 metric tons per year over the last 5 reporting years, 1969-74. The landings show an increase of more than 25 percent over a period of 9 years, with the greatest increases occurring in the catches from the east central Atlantic and West Indian Oceans. There is not sufficient information about the standing stocks of sharks, but Table 3 suggests that the present catch level can be tolerated without threat of depletion of the stocks. However, it must be remembered that sharks have a slow growth rate, implying that their availability and the economics of fishing for them can be altered relatively easily and that the time for replenishment of the depleted stocks would be so long that it could end the fishery.

**Table 2.—Some facts about some common sharks.**

| Common name(s) | Generic name | Features[1] | Danger rating[2] |
|---|---|---|---|
| Basking | *Cetorhinus maximus* | H,O | R |
| Blacktip (small) | *Carcharhinus limbatus* | G,L | O |
| Blacktip (large) | *Carcharhinus maculipinnis* | | O |
| Blue (great) | *Prionace glauca* | G | M |
| Brown, Sandbar | *Carcharhinus milberti* | L,F | M |
| Bull, (Lake Nicaragua) Whaler (Zambezi) Ganges | *Carcharhinus leucas* | | M |
| Common thresher, Fox Sea fox, Swingle Tail Thrasher, Whip tail | *Alopias vulpinus* | F,G | R |
| Dusky | *Carcharhinus obscurus* | L,F | R |
| Great hammerhead | *Sphyrna mokarran* | O,F | E |
| Great white | *Carcharodon carcharias* | F | E |
| Greenland | *Somniosis microcephalus* | P | R |
| Grey nurse | *Odontaspis arenarius* | | |
| Atlantic sand | *Odontaspis taurus* | L,F | M |
| Lemon | *Negaprion brevirostris* | | O |
| Mako, Bonito, Atlantic mako, Blue pointer Sharpnosed mackerel | *Isurus oxyrinchus* | G,G | E |
| Nurse | *Ginglymostoma cirratum* | L,F | E |
| Porbeagle, Mackerel | *Lamna nasus* | F,G | O |
| Soupfin | *Galeorhinus zyopterus* | F,O | R |
| Spiny dogfish | *Squalus acanthias* | F,L | R |
| Tiger | *Galeocerdo cuvieri* | F,G,L | E |
| Whale | *Rhincodon typus* | | R |
| Common whaler | *Galeolamna mmacrurus* | L | O |
| Whitetip | *Carcharhinus longimanus* | | M |

[1]H = hibernate, G= game fish, F = flesh used for food, L = hide good for leather, O = high oil content, P = flesh is poisonous.
[2]E = extreme danger to man, M = moderate danger, O = occasional danger, R= rare danger.

**Table 3.—World landings of sharks 1965-73 (in thousand metric tons).[1]**

| | Years | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| NW. Atlantic | 10.3 | 11.1 | 7.2 | 8.3 | 12.0 | 7.5 | 14.8 | 15.2 | 20.2 |
| NE. Atlantic | 64.2 | 67.6 | 78.6 | 74.8 | 88.7 | 78.0 | 66.3 | 69.4 | 69.5 |
| W. C. Atlantic | 9.2 | 9.6 | 10.1 | 10.6 | 9.6 | 6.8 | 7.3 | 7.5 | 9.6 |
| E. C. Atlantic | 9.4 | 8.7 | 7.3 | 11.8 | 12.8 | 36.7 | 42.1 | 48.2 | 48.4 |
| Mediterranean and Black Seas | 10.3 | 9.4 | 16.0 | 11.3 | 11.1 | 6.0 | 9.6 | 6.8 | 6.5 |
| SW. Atlantic | 14.4 | 14.8 | 22.4 | 23.3 | 19.8 | 18.7 | 19.1 | 18.2 | 22.2 |
| SE. Atlantic | 3.6 | 8.4 | 6.4 | 6.3 | 6.9 | 6.2 | 3.9 | 6.3 | 6.6 |
| W. Indian Ocean | 57.9 | 73.6 | 78.2 | 75.1 | 81.4 | 75.8 | 78.9 | 110.0 | 150.7 |
| E. Indian Ocean | 27.4 | 26.0 | 20.6 | 24.4 | 29.2 | 34.3 | 31.7 | 28.8 | 19.9 |
| NW. Pacific | 58.7 | 62.3 | 62.1 | 83.7 | 79.6 | 81.2 | 78.9 | 45.9 | 42.8 |
| NE. Pacific | 0.9 | 0.8 | 0.6 | 0.6 | 0.3 | 0.3 | 0.1 | 0.2 | 5.3 |
| W. C. Pacific | 10.7 | 12.7 | 10.2 | 14.6 | 16.1 | 17.4 | 15.5 | 17.3 | 7.4 |
| E. C. Pacific | 12.7 | 10.1 | 12.7 | 9.9 | 10.5 | 13.4 | 12.3 | 11.6 | 15.5 |
| SW. Pacific | 9.5 | 11.0 | 8.8 | 3.4 | 2.8 | 3.3 | 4.5 | 3.5 | 3.6 |
| SE. Pacific | 7.0 | 8.7 | 13.0 | 16.4 | 10.5 | 13.1 | 9.8 | 8.1 | 19.6 |
| Totals | 306.2 | 334.8 | 354.2 | 374.5 | 391.3 | 398.7 | 394.8 | 397.0 | 447.8 |

[1]From: FAO "Yearbook of fishery statistics—catches and landings, 1973." Vol. 36, 1974, 590 p.

## Sharks as Food for Man

The utilization of sharks for human food will probably increase in the future. The world's need for protein is growing at a rate greater than the rate of protein production. The pressure to obtain the protein from the sea is increasing. But many of the popular marine species are overfished and since sharks continue to feed on the already shrinking stocks and continue to cause considerable damage to fishing gear (in order to get to the fish held by the gear), it seems inevitable that fishing effort will have to be directed to sharks in order to reduce both the destruction of fishing gear and the predation on fish held in nets, etc., as much as to increase the harvest of marine protein. The yield of shark meat varies between 20 and 60 percent, depending on a number of factors. The yield varies among species, and generally male sharks yield more edible meat than female sharks of the same size. Females carrying unborn offspring have an even lower yield with about 15 percent of their weights attributable to the embryos within them.

### *Acceptability of Shark Meat*

The organoleptic qualities of shark meat vary, depending to some extent on species. Some species have a relatively good acceptability (e.g., spiny dogfish, *Squalus acanthus*), some species taste similar to tuna, halibut, etc., and shark steaks have been sold as halibut or

swordfish steaks. But some species are not as acceptable, with objections being attributed to sour and bitter off-flavors and to the odor of ammonia. The development of off-odors and off-flavors can be prevented by proper handling. Therefore, much of the unacceptability recorded is not due to an inherent poor quality of shark meat, but rather to poor handling practices.

Species of sharks considered to have the best eating qualities are mako[3], thresher, soupfin, mackerel, white, and spiny dogfish. The flavor of the blue shark is considered to be undesirable. The most desirable of the edible meat are the fillets and the flesh from the caudal peduncle, which together make up about 55 percent of the total edible portions. The belly flaps are considered a delicacy by the Germans, and the fins of all sharks have commercial value as food for humans, except for the fins of the nurse shark which contain no edible gelatin. The Norwegians use dogfish eggs as substitutes for hen's eggs in puddings and in other food preparations normally requiring eggs.

There are enough sharks in the world's oceans to permit a much greater harvest than is presently taken, but there are several reasons why the shark fishery is not expanding. A major deterrent is that shark flesh generates large amounts of ammonia when it is stored, due to its unusually high content of urea (amounts as high as 0.12 percent have been reported). It has been demonstrated that the conversion of urea to ammonia is due to ureases (urea splitting enzymes) produced by bacteria: $CO(NH_2)_2 + H_2O$ urease $2NH_3 + CO_2$.

The production of ammonia can be minimized by observing maximum sanitation practices in the handling of shark flesh and by keeping the holding temperatures as low as possible. Lowering the pH of shark meat by the addition of acid, such as citric acid, lemon juice, tomato juice, vinegar, etc., has been demonstrated to be effective in the elimination of the ammonia problem. It has been reported that the addition of acid provides an additional unexpected benefit—it improves the texture of the meat. Experiments have shown that the ammonia problem can be mitigated by washing shark meat with water which apparently removes urea. This suggests that a very effective washing would occur in mechanical deboning of sharks where the meat is obtained in a comminuted form with a corresponding large surface to facilitate the washing. As much as 60 percent of the urea has been removed from shark meat by soaking it in solutions of lactic acid (1.5 percent), or salt (1 percent), or in urease extract. Lactic acid seemed to be most effective. Heating the meat also lowers the urea content. A blanching treatment lowers it by about 10 percent. A heat-sterilizing treatment lowers it by about 30 percent. Urea has been removed successfully from shark meat that was salted by immersing in brine and then desalting. For any use of shark meat which requires soaking, however, it is necessary to blanch it first. Otherwise the soaked meat is reported to acquire an objectionable off-taste.

There may be a relationship between the human fear of sharks as man-eaters and the human resistance to shark meat as food, but in many areas, this relationship does not exist. For example, the English, Italians, Japanese, French, Swedes, Chinese, and others have no qualms about eating shark. It is reported that the English use about 17 million pounds (about 7,700 metric tons) of dogfish per year. They also consume small amounts of several other species of sharks.

The flavor and quality of shark meat and its products depend on effective bleeding of the shark carcass and sanitary handling practices. Bleeding can be done most effectively when it is done immediately after the shark is caught by chopping off the caudal fin. The heart, which will still be pumping, forces the blood out of the severed major artery. Other bleeding techniques, such as puncturing the heart or severing major arteries in other parts of the body, are much less effective. Sharks should then be eviscerated as soon as possible. At the processing plant or in a factory, the fins are generally removed to be used separately. Large sharks (larger than 3 or 4 feet) are generally cut transversely into steaks. Smaller sharks may be filleted. Shark meat is frozen by the same techniques used for freezing the steaks and fillets of other fish. The shark should be handled as little and as quickly as possible to keep quality deterioration to a minimum.

*Preservation Methods*

Shark meat may be preserved in a number of ways. It has been canned successfully during wartime, even though early attempts at canning were frustrated. While the formation of ammonia in shark meat is generally attributable to the breakdown of urea by bacterial ureases, it may also be formed in canned shark meat due to the heat which degrades the urea to ammonia. The conversion occurs at temperatures as low as 176°F (80°C). At 212°F (100°C), the conversion is quite rapid. The problem was eventually solved with the addition of acid which combined with and neutralized the liberated ammonia. The acceptability of canned shark meat was enhanced when the meat was packed with olive oil and peas (or beans) in a ratio of meat 50 parts, oil 25 parts, and peas 25 parts. The meat was cut in small pieces and blanched prior to packing.

Shark meat can be cured and smoked, and when processed in this manner the adverse contributions are minimized. Small pieces are soaked in water for about 6 hours then pickled in saturated brine for about 2½ days and smoked for about 1½ days. They are then held in trays at room temperature for about 2 weeks by which time the cure is complete.

Shark meat has been used for making sausages but, generally, required the addition of flesh of other species (e.g., hake) to produce an acceptable product. The Japanese prepare a paste-like product from shark meat after it has been separated from the skin and the cartilage and comminuted. Salt and various other spices are added and the paste is then molded into rolls which are steamed over boiling water for 20 minutes. The product, white in color, is considred to be quite acceptable by the Japanese. The Japanese also produce a smoked canned shark meat in soy marinade.

To produce salted dried fillets, sharks are beheaded, eviscerated, and

[3]Mako shark is also called bonito shark.

bled. They are then washed and stored in ice (belly down) until ready for use. Later they are filleted, and the fillets are cleaned of blood spots, skin, etc., and ragged edges are trimmed. The washed fillets are then drained for a few minutes and layered with salt in boxes containing drain holes, taking care that fillets do not overlap without salt between them. The boxes are held in the shade for about 6 days. At the end of this period the fillets are removed and excess salt is brushed off. The fillets are then dried by any of the available methods (tunnel drying, sun drying, etc.). Sun drying, which takes about 1 week, is the least desirable method because this process subjects the product to various types of contamination, and there is no way to control the precipitation, temperature, humidity, etc. Thus, when precipitation occurs or when the humidity is high, the fish, which are generally dried on racks or trays, must be removed to a covered drier area. In tunnel drying and cabinet drying, the product is protected against contamination and there are various conditions that are controllable (temperature, air flow, humidity, etc.), depending on the facilities. When conditions are controllable, the recommended temperature is about 113°F (45°C), and the recommended relative humidity is about 35 percent. Under these conditions, the drying time is much shorter than that required for sun-drying and the quality of the tunnel-dried product is correspondingly better. Del Valle and Nickerson (1968) developed a quick-salting process for shark meat. The process, requiring only simple equipment, produces an acceptable salted product, inexpensively, and has an excellent potential for preserving and making available a high value protein for inhabitants of developing countries where refrigeration is yet scarce. The process involves grinding shark flesh with the simultaneous addition of salt, pressing to remove water, and drying the pressed cakes in air or by other means when available. The dried product is stable without refrigeration, even at tropical temperatures. To prepare for consumption, the salt is leached out by boiling in fresh water 2 or 3 times. The resultant product remains intact and has a meaty flavor.

Shark meat can be cut into fillets or steaks which can be handled as fresh cuts, or they can be frozen. Shark fillets can be used to produce frozen fillet blocks.

The Norwegians, who export sharks, use an effective preservation process that is reported to keep sharks in prime quality for long periods. They cut away the viscera, including the belly flaps, and they pack the fish in an alginate jelly and place them in frozen storage at about 5°F (−15°C).

Fins are preserved by drying, freezing, or salting. To produce lightly salted dried fins, they must be trimmed of all flesh and skin, washed, and held for about 10 hours in a 3 percent salt solution (about ¼ pound of salt for every gallon of water). The fins are then sun-dried on wire mesh in single layers for about 2 weeks. When the drying is completed, the fins will be very stiff. They are then packed in boxes in which they may be shipped or held until shipped.

### *Composition and Characteristics*

Shark meat contains very little fat (as low as 0.1 percent in some species). A few species may have a fat content higher than 6 percent. Generally, shark meat is darker, coarser fibered, tougher, and stronger tasting than the meat of teleosts. The older the sharks, the stronger the taste. Shark meat is reported to be lower in protein value, contains less quantities of some of the essential amino acids, and has less quantities of total free amino acids than the meat of teleosts, and it has unusually high urea (up to 0.12 percent) and trimethylamine oxide (up to 1 percent) contents. Shark meat is more acidic than that of teleost fishes.

A component of shark liver oil is squalene, an unsaturated terpene hydrocarbon having the formula $C_{30}H_{50}$. It comprises the bulk of the unsaponfiable fraction of the liver oil in some sharks, and it was a by-product of the process that produced vitamin A from shark liver oil prior to the advent of synthetic vitamin A. It is noteworthy that squalene was mixed with cheap vegetable oils and used as an inexpensively produced, illegal, substitute for olive oil. The substitution was an excellent and valuable outlet for an otherwise low-value by-product, and it was made possible by the fact that the Food and Drug Administration (FDA) test for olive oil purity was related to the squalene content of the oil. When the practice was later discovered by the FDA it was, of course, terminated.

Some shark meat is poisonous. For instance, the meat of the Greenland shark, *Somniosus microcephalus,* is quite poisonous to both man and animals. Other species reported to be mildly poisonous are the black-tipped sand shark, *Carcharhinus melanopterus,* the seven-gilled shark, *Heptranchias perlo,* and the six-gilled shark, *Hexanchus grisseus.*

Except for the Greenland shark, the flesh of the sharks cited above are not very poisonous and one report indicates that the causative agent may be sufficiently washed away by rinsing the meat several times. Apparently there is considerable danger in eating the livers of these sharks where the concentration of the harmful substance not yet identified must be in more concentrated form.

Symptoms of poisoning from eating shark develop within 30 minutes. They include nausea, vomiting, diarrhea, abdominal pain, headache, aching joints, tingling about the mouth, burning sensation of tongue, throat, and esophagus, and, later, lack of coordination. If the illness is severe enough, there is paralysis, coma, and finally death. Although vitamin A in high concentrations (such as found in shark livers) is toxic, it is not the agent that causes the symptoms cited above.

### *Harvesting of Sharks*

Fishing for sharks must be closely managed; otherwise, the stocks may be depleted even more easily than those of other species. Such a problem has already occurred with the porbeagle, a shark averaging 5 feet (1.53 m) in length and 250 pounds (114 kg) in weight and fished largely for the European market. Thus, controls have been

placed on the fishing effort for this species in some areas. Prominent factors that contribute to easy depletion of the stocks are the small number of offspring produced by each female and their slow growth rate. The spiny dogfish has been fished from time to time, especially to minimize its nuisance effect. However, when a market demand was developed and the fishing effort became intense, the stocks were reduced rather quickly.

The village of Maloy in Norway is called the dogfish capitol of the world. From this port about 40 vessels, 70-90 feet (21.5-27.5 m) long, fish for small sharks. The bait is mackerel or herring, the gear is the long line, the hook is size 7. Each vessel carries 80-100 sections of line containing as many as 1,500 hooks. The lines are set through stern chutes and retrieved by hydraulic power, With crews of 8-10 men, these vessels stay at sea for 7-14 days. The fish are iced whole at sea. The gear that is used to catch sharks has to be constructed of very tough materials; ideally it should be made of steel cable or steel chain.

There are five generally accepted methods for fishing sharks with variations to suit different situations:

1) Set gill nets are used inshore. The nets are of webbing 10- or 11-inch (25.5- or 28-cm) stretched mesh, hung 20-30 meshes deep, and 2,000-2,500 feet (610-760 m) long. This length is attained by joining a number of nets. The upper part of the net is held up by uniformly spaced cork floats while the bottom is stretched downwards by lead weights. The amount of stretch imposed is such that three meshes occupy the lateral space of two fully stretched meshes. The net, anchored and marked with a buoy, is pulled aboard the boat once each day or less often, depending on the abundance of fish and the weather. If the net is hauled in much sooner, the catch may not be large enough to warrant the effort. If the net is not hauled in soon enough, the catch may be eaten by fish that are too small to trap and these would include small sharks, hagfishes, etc.

2) Drift gill nets are used in deep offshore waters and they may be strung 50-60 meshes deep. The web is hung so that two meshes occupy the lateral space of one fully stretched mesh, and the length of the net is about three times longer than the set gill net. Because of the extreme stresses placed on the drift gill net during hauling, especially in active or rough seas, the horizontal top line has to be extra strong.

Dogfish shark. (Photo by William L. High.)

3) Otter trawls are used for dogfish. The otter trawl is a cone-shaped net dragged with the large end forward, and the opening is maintained by "doors" which are placed in such a way that the forward motion tends to make them spread apart from each other, thus spreading open the mouth of the net.

4) Harpoons may be used to capture the large sharks.

5) The hook and line method involves the stringing of long lines (up to 2,000 feet (610 m) long) carrying baited hooks set about 12 feet (3.65 m) apart. This form of fishing is now less popular than gillnetting. Some longlining similar to that used for catching tuna may be used to capture medium-sized sharks.

## Nonfood Uses of Shark

Sharks have unique characteristics that have promoted their utilization in a variety of nonfood uses which include the production of shark leather, pharmaceuticals, at one time vitamin A, and other miscellaneous uses.

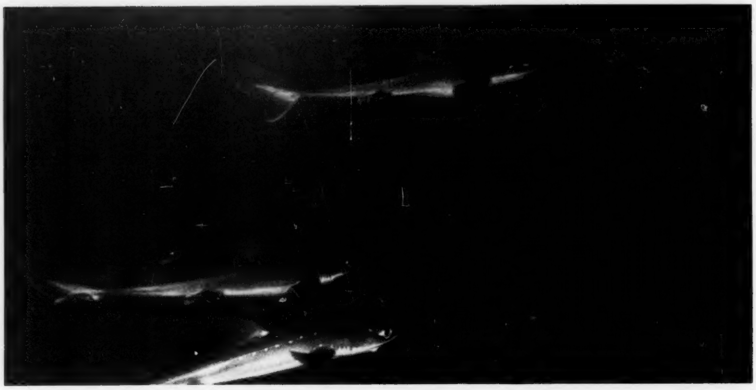
### *Leather*

The skins of many sharks can be processed to produce high quality leathers. In most cases the denticles are removed because their presence makes it very difficult to cut and stitch the leather, but in a few cases the denticles are not removed. However, in the latter case, the sharp denticles must be made dull; otherwise, the consumer would certainly be injured by them. It is when the denticles are left in that the leather is quite skidproof because even though their points are dulled, they still provide a considerable clinging ability. To remove the skin from a shark is said to tire the strongest men and to dull the sharpest knives, and it takes an expert at least 15 minutes to skin a shark. The toughness and wearability of shark skin leather is such that it outlasts steerhides and pigskins by about 100 percent. The tensile strength of shark leather is about 150 percent that of steerhide and pigskin. Because of the high costs of preparing shark skins, only those from the larger sharks (over 5 feet (1.53 m) in length) are used. However, theoretically, the skins of even the smallest sharks can be used when the economics of preparing them are feasible.

The production of leather from shark skins is similar to the process used for other marine fishes as well as marine mammals and land animals. This description will apply to the production of shark leather only, and for a more general description of the processing of hides and skins into leather, the reader is referred to O'Flaherty et al. (1956-1965). For details on the production of shark leathers the reader is referred to Rogers[4] and Kohler[5].

[4]Rogers, A. Sharkskins preparatory to tanning. U.S. patent 1,338,531 (1920). Preserving sharkskins and the like. U.S. patent 1,395,773 (1921). Treating sharkskins and the like. U.S. patent 1,412,968 (1922).

[5]Kohler, T. H. 1925. Tanning and dearmoring fish skins. U.S. patent 1,524,039, January 1927.



School of dogfish sharks. (Photo by William L. High.)

Leather production is a series of steps which includes preparation, tanning, and finishing. The skins of sharks are difficult to preserve because of the structure of their denticular scales which protect microbes lodged among them. The most desirable method for preserving shark skins would seem to be with ionizing radiation since this form of energy could destroy all deteriorative microorganisms no matter how well protected they might be from other preservation treatments. Radiation was demonstrated to preserve animal hides for long periods at room temperatures but its use has not been adopted for this purpose, as far as I know. The preserved skins may be stored until they are to be processed.

To remove the skin from a shark, the tail is cut at about the beginning of the caudal peduncle as the skin over this area is not used. (The fins of sharks are removed first since they can be readily sold as food in a number of overseas markets.) The skin is cut, starting at the holes left by the removal of the dorsal fins, along the backbone from end to end. A cut is then made over the top of the snout. This cut is then continued toward the back along the side of the head in a line just above the gill slits around the pectoral fin and back towards the front in a line that runs under the gill slits and parallel to the line above the gill slits. The cut continues along the lower jaw near, and following, the opening of the mouth where it meets the cut made on the other side of the head. Next the skin is gripped with one hand and pulled as the knife is used with the other hand to cut the skin away from the meat, the first hand continually pulling in a peeling action. An important factor in keeping the peeling time down to a minimum and in producing well-cut hides is the sharpness of the knife. It must be very sharp. However, it is because of this, precisely, that extreme care must be taken if accidental cutting of the skin (which detracts from its value and might even ruin it) is to be avoided. Thus, it is better to cut a little deeper even though this means more meat must be trimmed from the skin than to try to cut a clean skin (with no meat attached to it) and run the risk of cutting the skin.

As soon as the skin is removed from the shark, it must be washed to remove the blood and slime. It is then immersed in a vat containing about 3.5 percent sodium chloride (table salt). The skin is held in the brine 3-8 hours and then the flesh is removed. After fleshing, the skin may be trimmed, if necessary, and then given a final wash. The skins are then layered with salt in piles about 3 feet (0.92 m) high on platforms that are slightly inclined so that all liquid will be drained away from the bottom layers of skins. They should not be placed in the sun. After 4 or 5 days the skins are cured (they should not remain in the pile for longer than 1 week).

Following this, each hide is shaken to remove excess salt. It is then placed flesh side up, sprinkled with new salt, and its edges are folded in to make a square. The square is then made into a roll and tied. The individual bundles are packed in bags of burlap or sisal or in barrels. They are held or shipped to the tannery in this form.

To produce leather from skins, they are soaked to remove salt and/or to rehydrate them (depending on the preservation process used). They are then put in vats containing lime (calcium hydroxide), usually in concentrations such that the weight of the lime is about 10 percent of the weight of the hides. The pH of the solution should be about 12.5. The lime soak is used to loosen the denticles. Sodium sulfate in an amount equal to about 2 percent of the lime (by weight) is also added to enhance the effectiveness of the lime. Several lime treatments (using fresh lime in each case) may be required.

Any flesh that remains on the skins is trimmed off and the skins are then bated. Bating involves the use of proteolytic enzymes to hydrolyze the fibers which enhances swelling of the skin. Since bating acts best at pH 8.5, acid is added to the bating solution in order to lower the pH of the skins to the desired level.

Tanning enables the skins to resist degradation from many environmental conditions as well as from microbes. Because of the unique characteristics of shark skin, it is tanned only by the vegetable tanning process. Vegetable tanning employs the extract of either the bark or of the bark and wood of a variety of trees that include oak and hemlock. This part of the process is carried out in vats and takes 1 or more weeks, depending mainly on the types and physical characteristics of the skins.

After tanning, the skins are lubricated with oils and greases to replace natural fats that were removed in the preparation and tanning processes. This step, called "fat-liquoring," improves the strength, resistance, and flexibility of the skins. The skins may then be dyed using a variety of aniline dyes. The skins are then shaved to the desired thickness and passed between rolls that press out excess water and iron out wrinkles. They are then dried by pasting them on flat surfaces and passing

them through drying tunnels. The dyed skins are then given a surface finish either by hand or by machines which may or may not include a glaze.

Brody (1965) quotes an official of the Ocean Leather Corporation[6], a manufacturer of shark leather, as reporting that when the toe part of children's (especially boys') shoes are made of shark skin such shoes do not abrade or scuff as do shoes made of conventional leathers. Since the toe part of the shoes of children receives the most wear, the shark skin shoes last significantly longer than shoes made with conventional leather only.

The skins of the male sharks are preferred to those of female sharks. The reason for this is that the hides of the females usually contain mating scars which at best result in visible imperfections in the leather and at worst result in holes in the leather (see section on Reproduction).

*Pharmaceuticals*

Sharks have been studied for their pharmaceutical value, and heparin-like compounds have been found in nearly all parts of dogfish (a small shark) that have potencies far in excess of that of commercial heparin, while at the same time the shark compounds cause less undesirable side effects than does heparin. Commercial heparin, a derivative of body tissues, especially the liver, is produced from animals. It is prescribed for individuals who have a tendency to form blood clots.

In the late 1930's the discovery that dogfish liver oil contained about 10 times the amount of vitamin A contained in cod liver oil, followed by the discovery that the liver oil of the soupfin shark contained about 100 times the amount of vitamin A contained in cod liver oil, started a shark-fishing activity of such intensity that it was likened to a gold rush. By 1942 the price of sharks had risen to $1,500 per ton from a price of about $10 per ton in 1938. The oil obtained from the liver of sharks has been used in tanning as well as a source of vitamin A. The value of fish oils as a source of vitamin A has been reduced sharply since the advent of the process for producing synthetic vitamin A in the late 1940's. However, there is a concern among some that the synthetic substitute may be inferior to the fish liver oils because it lacks minerals, amino acids, and possibly other unidentified nutrients. Prior to the changeover to synthetic vitamin A, shark livers sold for as high as $1.50 per pound, depending on the vitamin content. The vitamin A content of shark livers covers a broad range, and the richer oils have been reported to contain up to 340,000 U.S.P. units per gram of oil.

In order to preserve the quality of the liver oil, it must be recovered soon after the sharks are slaughtered. When livers cannot be processed, their quality will diminish unless they are effectively preserved. Held in frozen storage, the livers will retain their good quality for months. Livers may be preserved also by salting (finished concentration to be about 10 percent by weight), by the addition of Formalin (about 0.25 percent by weight), and by other miscellaneous methods, but the freezing preservation is the most effective process for protecting the quality of the livers.

Prior to processing the livers, they must be cleaned of all other material. The livers are then comminuted and this can be accomplished by a variety of machines such as hammermills, disintegraters, choppers, etc. The comminuted livers are then heated in pots, jacketed kettles, or by direct steam injection which renders out the oil which can then be decanted or centrifuged. The oil may also be rendered by hydraulic pressure or under heat and pressure. It may also be recovered through an alkali digestion method or by an enzyme/alkali digestion method (alkali digestion methods are the most popular ones). In most cases a centrifuge is used to separate the oil from the aqueous layer. Once the oil is recovered it must be preserved to retain its quality until it is used. It is best stored in drums with no head space and in a cool area.

The oil must meet stringent physical and chemical specifications. The oil is processed into liver oil capsules or in multiple vitamin capsules containing other vitamins. When the vitamin A of an oil is relatively low, it can be concentrated by the saponification process which carries the vitamin A in the unsaponifiable fraction from which it can be recovered in a concentrated form by solvent extraction and further purification.

In some work conducted when shark liver oil was used as a source of vitamin A, it was observed that the shark liver oil promoted the growth of white blood cells. Although there is no evidence to support the theory that shark liver oil contains an anticancer agent, sharks apparently do not develop tumors of any kind, and this fact continues to generate hopeful interest in finding the reason why sharks are not vulnerable to one of man's most dreaded diseases. In some work conducted by John Heller, Executive Director of the New England Institute for Medical Research in Ridgefield, Conn., shark liver extract was reportedly used successfully to treat cancer in mice, rats, and chickens. It is suggested by some researchers that sharks are immune to other diseases as well as to cancer and that they do not show old age weaknesses. In one study the addition of antibodies from shark blood to a growth medium inhibited the growth of a variety of microorganisms that cause diseases in man.

*Miscellaneous Uses*

Sharks have other miscellaneous uses. The teeth of sharks have been used for producing novelty items, knives, shark tooth gauntlets, as well as other weapons of defense. Because the scales on shark skins are hard, sharp, and close together, shark skins have been used in the past by wood-workers for abrading wood. However, this use is neither economical nor practical in light of the modern effective sandpapers available today. Shark skins have been used to polish marble. Because of the nonskid property of shark leather, it was used for making sword hilts to insure retention of possession of the sword for its owner. This property has been used to produce pickpocket-proof wallets. The use of urea in shark meat

[6]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

has been considered as a feed component for farm animals. Ruminants such as cattle and sheep can utilize the urea in sharks in limited amounts (less than 0.025 percent). Even chicks have been reported to utilize urea; however a protein deficiency might result without an added protein supplement.

### Danger to Man

The danger of sharks to man is real although it may not be as prodigious as their notoriety would imply. Most sharks are too small, too sluggish, or are just not that dangerous. However, some species (e.g., white shark and tiger shark) are large enough, fast enough, powerful enough, and aggressive enough to be extremely dangerous to man. About 35 species of sharks are considered to be potentially dangerous to man so it is not unreasonable to find that there are about 50 cases of shark attacks on people reported annually of which less than 50 percent are fatal. One can only guess at the number of shark attacks that are not reported. Shark attacks occur more frequently in warm waters than in cold waters and seem to occur more often at night than during daylight. The reason for the former is that the dangerous species are natural inhabitants of warm waters. The reason for the latter may be due to higher nocturnal activities of sharks or the inability of many to sight sharks at night, or both. It is relevant to note, however, that in a study of shark behavior, it was observed the sharks in one area migrated to offshore during the day and came close to shore during the night where they remained until daybreak. This pattern was observed over a number of days and nights. The pattern indicated that the sharks had set up a territory that ranged from inshore to offshore. It is suggested by some that the reason for at least some shark attacks on man are due to the territorial jealousy of sharks that makes them interpret man's presence as a threat to their waters. This concept is believed to be supported by the fact that when bathing beaches are protected by entrapment nets, the number of sharks trapped is reduced with time, until eventually there are no sharks caught. There seems to be no doubt that the presence of blood incites sharks to ferocious attacks on any object near the blood, at any time, day or night.

The damage inflicted by sharks is not limited to their numerous sharp teeth, powerful jaws, and, in some cases, spikes. The sharp denticles on their skin can also inflict considerable damage on bare skin. The great shark scare during the first 12 days of July in 1916 off the New Jersey coast was not just a scare. It cost the coastal cities about $1 million in cancelled reservations as well as the lives of several citizens that were killed by sharks on New Jersey beaches. In at least one of these cases, both the tibia and fibula (leg bones) were actually snapped off below the knee, giving proof the awesome crushing power of the jaws of the shark. It was concluded that white sharks were involved since one of them, which was later caught in the general area of the attacks, contained parts of human anatomy in its stomach. In 1959, California suffered a similar shark scare in which again several people were killed. Again white sharks were involved.

The most devastating shark attacks on man have occurred when large vessels have been sunk in shark-infested waters. In some of these cases, the number of people killed by sharks have numbered in the hundreds. In the sinking of the U.S. cruiser *Indianapolis,* during World War II, nearly a thousand men were lost at sea. Although the toll taken by sharks is not known exactly, nearly 100 shark-mutilated bodies were later recovered. In the sinking of troopship *Nova Scotia,* in the same war, about 1,000 men were lost, and in this tragedy many bodies were recovered, still in their life jackets, but without legs. Sharks apparently attack the limbs because they appear easier to sever than the torso. Yet, there are a large number of reports that sharks were discouraged by different actions taken by potential victims. The accounts do not enable one to arrive at any pattern that could be used to defend against sharks, but nude persons are more readily attacked than clothed persons.

There seems to be no conclusive evidence that sharks attack those that emanate fear signals, although some incidents might suggest this. On the other hand, it has been observed that when a shark closes in on a group of bathers, it generally selects one and continues to attack his selected victim in spite of the presence and even the actions of the others. This may only seem so, since blood, usually drawn at the first attack even if made randomly, would then attract the shark to the bleeding person. There is evidence to suggest that sharks attack light-skinned people more readily than they attack dark-skinned people. When all factors, clues, facts, etc., are analyzed and evaluated, we can only conclude that shark behavior and motivation are unpredictable, and sharks just cannot be ignored if there is any chance that they may be near bathers. The term "rogue shark" has been used in the literature. A rogue shark is a lone hunter who usually has attacked at least one human being and has the inclination to attack others.

The military, especially, has been interested in sharks because of the hazard to downed flyers and to naval personnel that either accidentally or by necessity must spend time in the water without the protection of any type of vessel. Until World War II, the danger of sharks to man was not fully appreciated, but following unexpected losses of Navy personnel to sharks, the U.S. Navy became concerned and launched research to find shark repellents.

In 1944, the Navy disclosed "Shark Chaser," a water-soluble cake consisting of black dye (about 80 percent) and copper acetate (about 20 percent). The purpose of the dye was to obscure man from sharks and the copper acetate was found to repel sharks in initial experiments. In subsequent uses of shark chaser, it was found to work sometimes, but not always. It is not considered effective against the white shark, nor is it effective when shark activity is aroused. Some experiments showed that human sweat repelled sharks, but not reliably. Of the many shark repellents and shark barriers tested, none have been proven 100 percent effective. Injections of numerous poisons, enough to kill large animals, did not kill sharks. Only strychnine was effective,

but since the sharks took up to 30 seconds to respond, the question is how much damage can a shark do in 30 seconds?

The most effective barrier at beaches is believed to be wire mesh. For protection of humans in the ocean, an opaque inflatable bag is believed to be effective. The device keeps the person at the surface while at the same time he cannot be seen or smelled by sharks. However, bags have been bitten by sharks and the effectiveness of the bags as protection against sharks is yet to be determined. "Kevlor", a synthetic bullet-proof fabric manufactured by the DuPont Company, has been demonstrated to be effective against tearing by sharks. This is still under study.

The only truly effective protection for humans is the cage. Made of steel bars, it is used to enclose those engaged in underwater photography, etc. A new and promising repelling device called "the Hicks repeller" produces pulsed electromagnetic fields that are said to cause sharks such unbearable annoyance that they move quickly away from the repeller. Although the device emits explosive sounds, its effectiveness is believed to be due to the electrical effect on the ampullae which is described, literally, as a nervous breakdown.

A most promising repellent reported in the literature to date is a naturally occurring one. It is a highly lethal milky toxin secreted from surface glands along the dorsal and anal fins of a small flatfish, *Pardachirus marmoratus,* that inhabits the Red Sea. It is called the "Moses sole" by the Israelis who find it to be good eating. Since the fish is cooked prior to consumption, its toxin is presumably destroyed by heat. In experiments conducted by Clark (1974), sharks that attempt to devour this flatfish seem to undergo an immediate paralysis of the jaw in the open position because the observer reported that the attacking shark did not close its mouth even after it had retreated from its prey. Repeated experiments produced the same results—in no case was the little fish in any danger. This apparent shark repellent is so powerful that even in very dilute amounts it kills small marine animals. Laboratory studies of its action indicated that the toxin appears to attack the nerves and, in addition, it destroys red blood cells.

Of the weapons used to kill sharks, the most desirable one seems to be the carbon dioxide dart gun. By this means, the shark is killed and inflated with carbon dioxide gas which floats the shark to the surface where it can be seen and taken out of the water if it is advantageous to do so. An additional feature to this weapon is that it does not shed blood. This is important when there are other sharks in the vicinity since the presence of blood in the water incites them to violent attacks. Other effective weapons are "death needles" loaded with strychnine and the "powerhead", a device to be used like a hammer which fires a 12-gauge shotgun shell, usually to the shark's brain.

The American Institute of Biological Sciences maintains a Shark Research Panel that records information relative to shark attacks on man and defenses against shark attacks and promotes research to broaden the information base on sharks.

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MFR PAPER 1282

# Relationship Between Size Composition and Ex-Vessel Value of Reported Shrimp Catches From Two Gulf Coast States With Different Harvesting Strategies

CHARLES W. CAILLOUET and FRANK J. PATELLA

*ABSTRACT—This paper describes the effect on ex-vessel value of size composition of reported catches of brown shrimp,* Penaeus aztecus, *and white shrimp,* P. setiferus, *from Texas and Louisiana, two Gulf Coast States with different shrimping regulations and harvesting strategies.*

## INTRODUCTION

Shrimping regulations and harvesting strategies differ appreciably between Texas and Louisiana, which together produce 75 percent of the shrimp landed from the northern half of the Gulf of Mexico. In Texas, shrimping regulations greatly restrict the catch of small shrimp, whereas in Louisiana there are few restrictions on the catch of small shrimp. The results of these regulations are that the bulk of the catch for Texas comes from an offshore fishery, mostly for large brown shrimp, *Penaeus aztecus*, with a smaller portion of the catch coming from an inshore (tidal waters landward of the Gulf) fishery, primarily for both small and large white shrimp, *P. setiferus*. In Louisiana, there is a substantial inshore fishery and an offshore fishery for both small and large brown and white shrimp.

In this paper we illustrate the effect of size composition of reported brown and white shrimp catches on the ex-vessel value of these catches in the two states.

## BRIEF DESCRIPTION OF FISHERY AND DATA

Brown and white shrimp, the two dominant species in Texas and Louisiana, spend the juvenile and subadult phases of their life cycles in inshore waters, and the adult and larval phases in offshore waters. Harvesting of these shrimp begins when they are in the juvenile phase.

Texas state shrimping regulations include: Licenses, limits on the number and size of trawls and trawl mesh size, daily catch limits, size limits on food shrimp (not on bait shrimp), closed areas and seasons, and size limits on food shrimp during the fall open season. Size limits on food shrimp and a closed season (usually 1 June-15 July) also are applied to shrimping offshore (seaward of the beach). In addition, no nighttime shrimping is allowed in inshore waters. Louisiana state regulations on inshore shrimping include: Licenses, limits on the number and size of trawls and trawl mesh size, size limits on white shrimp, and closed seasons. There are no catch limits, and nighttime shrimping with "butterfly" or wing nets is allowed. Size limits on white shrimp also are applied to offshore shrimping.

Numbers of vessels (5 net registry tons and larger, Fig. 1) and numbers of boats (less than 5 net registry tons, Fig. 2) differ between the two states, and the vessels in Texas average larger than those in Louisiana (Fig. 3). Texas exceeds Louisiana in number of fishermen

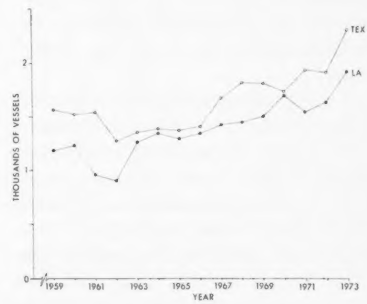


Figure 1.—Reported annual number (thousands) of vessels (5 net registry tons or larger) in Texas and Louisiana, 1959-73.

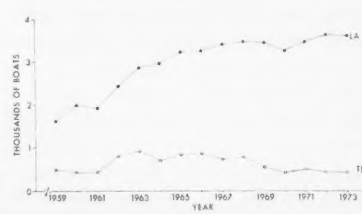


Figure 2.—Reported annual number (thousands) of boats (less than 5 net registry tons) in Texas and Louisiana, 1959-73.

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operating from vessels whereas Louisiana exceeds Texas in the number operating from boats (Figs. 4 and 5).

This paper deals only with reported annual (1959-75) catches (pounds, heads-off) of brown and white shrimp from two regions: Texas coast (statistical areas 18-21) and Mississippi River to Texas (statistical areas 13-17) (Fig. 6). These zones represent the Texas coast and that part of the Louisiana coast west of the Mississippi River, respectively. Combined inshore and offshore catches were used.

Annual catches reported in the Gulf Coast Shrimp Data (Current Fisheries Statistics) represent only a portion of the total annual catches from inshore and offshore fisheries (Fig. 7). Some of the commercial landings, discarded undersized shrimp, and landings by sport fishermen are not sampled and therefore go unreported. The proportion of the total annual catch not reported is unknown, but we believe that the size composition of the reported catch is a reasonably good reflection of shrimp population characteristics and harvesting strategy combined. Annual summaries of reported catch (pounds,

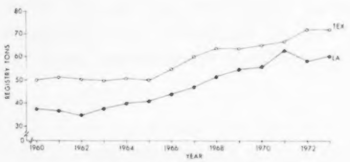



Figure 3.—Annual average reported registry tons per vessel (5 net registry tons or larger) in Texas and Louisiana, 1960-73.

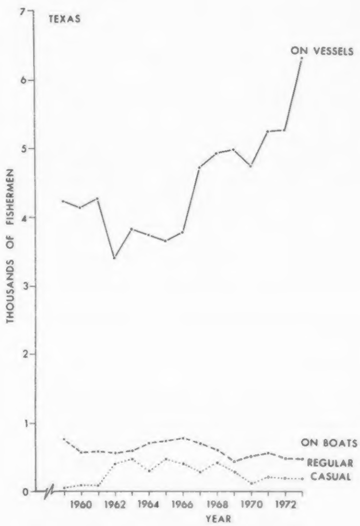



Figure 4.—Reported annual number (thousands) of Texas fishermen who shrimped on vessels (5 net registry tons or larger) and boats (less than 5 registry tons), 1959-73.

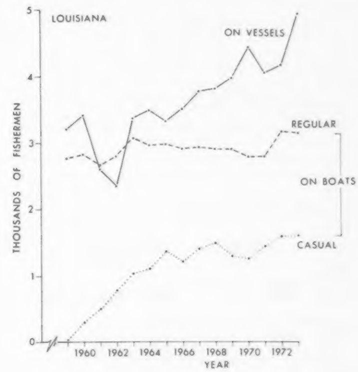
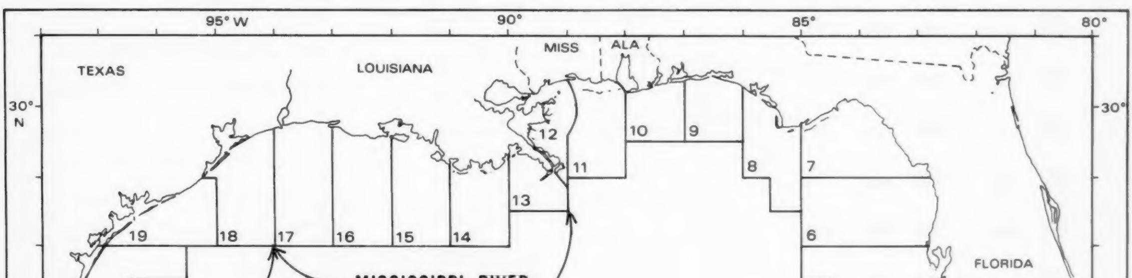



Figure 5.—Reported annual number (thousands) of Louisiana fishermen who shrimped on vessels (5 net registry tons or larger) and boats (less than 5 net registry tons), 1959-73.

Figure 6.—Statistical areas used in reporting gulf coast shrimp data.



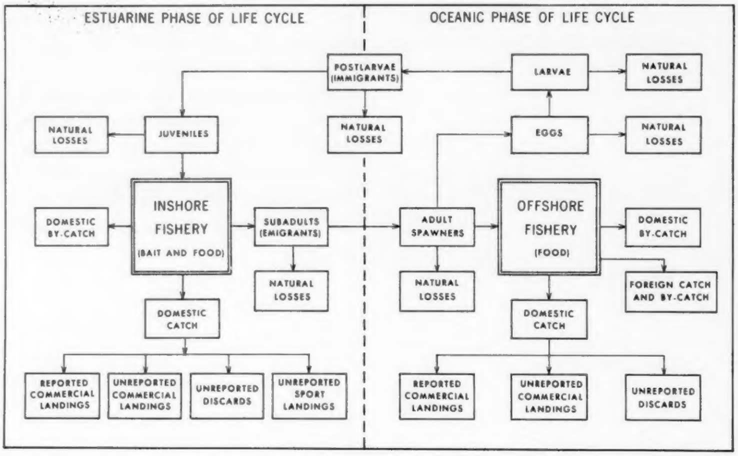



Figure 7.—Relationship between inshore and offshore shrimp fisheries and estuarine and oceanic phases of the brown and white shrimp life cycle.

heads-off) are made by eight size categories (number of shrimp per pound: 68 and over, 51-67, 41-50, 31-40, 26-30, 21-25, 15-20, and under 15) in the Gulf Coast Shrimp Data.

Species composition of the reported catches has been rather stable in Texas, but in Louisiana there has been some variation from year to year, the catch being dominated alternately by brown or white shrimp (Fig. 8). Size composition of the reported catches of brown and white shrimp has remained remarkably constant (except for 1959) within the two states despite wide variation in annual catch from year to year in response to fluctuation in recruitment (Figs. 9-12). In recent years, however,

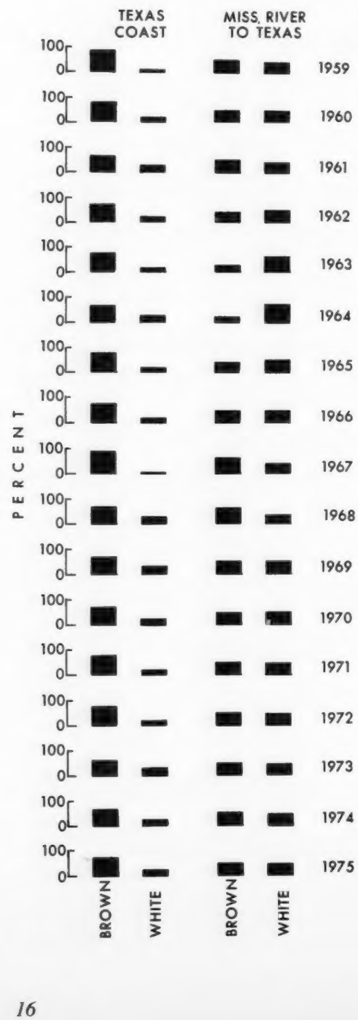



Figure 8.—Species composition (percent, by weight, heads-off) of reported annual catches of shrimp from Texas coast (statistical areas 18-21) and Mississippi River to Texas (statistical areas 13-17), 1959-75.

Figure 9.—Size (number per pound, heads-off) composition (percent, by weight) of reported annual catches of brown shrimp from Texas coast (statistical areas 18-21), 1959-75.

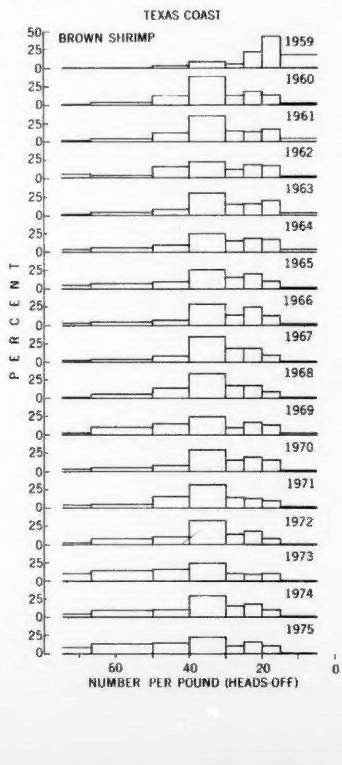
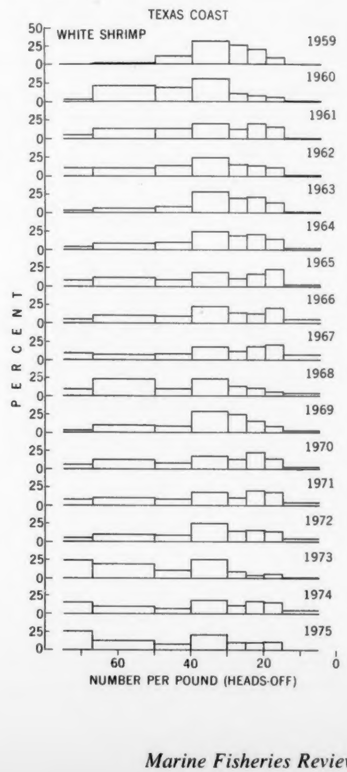



Figure 10.—Size (number per pound, heads-off) composition (percent, by weight) of reported annual catches of white shrimp from Texas coast (statistical areas 18-21), 1959-75.



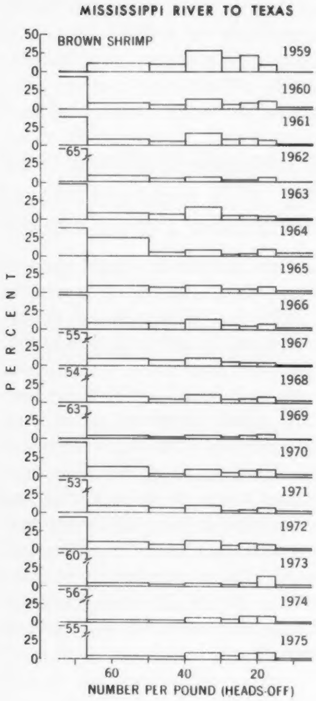



Figure 11.—Size (number per pound, heads-off) composition (percent, by weight) of reported annual catches of brown shrimp from Mississippi River to Texas (statistical areas 13-17), 1959-75.

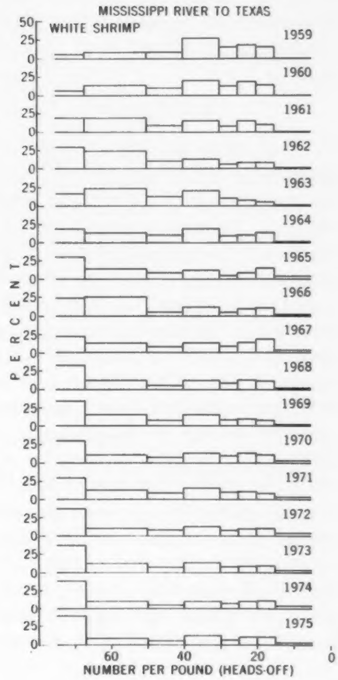



Figure 12.—Size (number per pound, heads-off) composition (percent, by weight) of reported annual catches of white shrimp from Mississippi River to Texas (statistical areas 13-17), 1959-75.

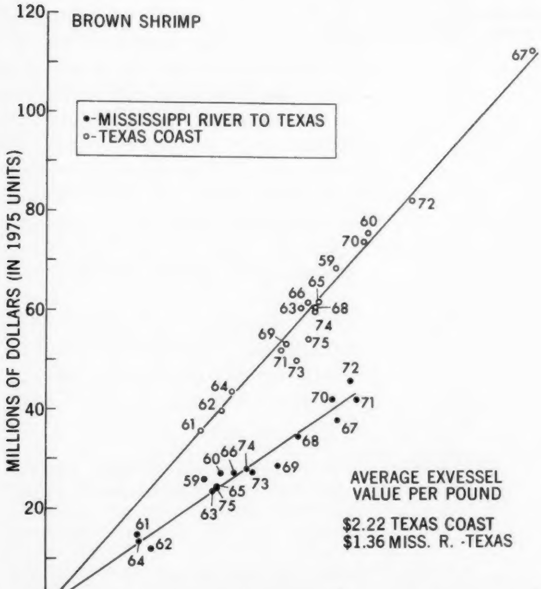



Figure 13 (Below, left).—Relationship between estimated ex-vessel value (millions of dollars in 1975 units) of reported annual catches (millions of pounds, heads-off) of brown shrimp from Texas coast (statistical areas 18-21) and Mississippi River to Texas (statistical areas 13-17), 1959-75.

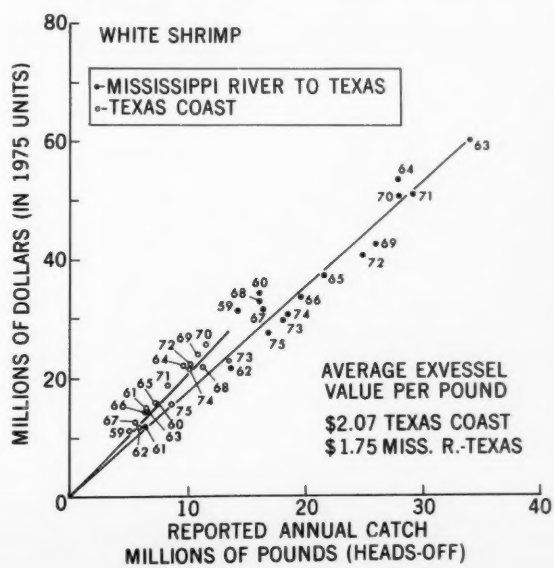



Figure 14.—Relationship between estimated ex-vessel value (millions of dollars in 1975 units) of reported annual catches (millions of pounds, heads-off) of white shrimp from Texas coast (statistical areas 18-21) and Mississippi River to Texas (statistical areas 13-17), 1959-75.

there is evidence of increase in the proportion of reported white shrimp catches in the 68-and-over size category.

## METHODS

To illustrate the effect of size composition on the ex-vessel value of the reported catches of both species in both regions, average value per pound (heads-off) was calculated from annual total dollars and pounds by size category (for the entire U.S. gulf coast) as reported in "Shrimp Landings, Annual Summary 1975" (Current Fisheries Statistics No. 6924). These averages were then multiplied by the annual total reported catches to obtain value (in 1975 units) of these catches by size category, species, and region. Summation over size categories provided total annual value (in 1975 units) of these catches by species and region. Data from 1975 were used because there is considerable time lapse between collection and reporting of such fisheries statistics. Similar methods could be applied as more current statistics become available.

## RESULTS

Annual value of the catches is plotted against weight of the catches for brown shrimp (Fig. 13) and white shrimp (Fig. 14). Least squares regression lines were fitted to the data points and through the origin for each species and each region to estimate average value per pound (the slope of the line). The points fall remarkably close to the lines in all cases, further demonstrating the stability in size composition of the catches over the 17-year period. For brown shrimp, the average ex-vessel value per pound for the Texas coast was 1.6 times that for the Mississippi River-to-Texas region. For white shrimp, the average ex-vessel value per pound for the Texas coast was 1.2 times that for the Mississippi River-to-Texas region. White shrimp spend a greater portion of their life cycle in inshore waters than do brown shrimp. This, coupled with the concentration of fishing for white shrimp in inshore waters, contributes to the smaller difference in average value per pound of white shrimp between Texas coast and Mississippi River-to-Texas areas, as compared with brown shrimp.

## MANAGEMENT IMPLICATIONS

It is clear that the ex-vessel value of the shrimp catch, harvested at smaller sizes from the Mississippi River-to-Texas region, is lower in that region than for the Texas coast, a result that many who are familiar with these fisheries are acutely aware of. Apart from the differences in value of the catches to the fishermen, however, there are considerations to be given to social and other economic impacts of shrimp harvesting strategies used in Texas and Louisiana. This paper merely stresses the need to investigate socioeconomic impacts of alternative shrimp harvesting strategies.

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MFR PAPER 1283

# Sea Scallop Resources off the Northeastern U.S. Coast, 1975

CLYDE L. MacKENZIE, Jr., ARTHUR S. MERRILL, and FREDRIC M. SERCHUK

## INTRODUCTION

The sea scallop, *Placopecten magellanicus* (Gmelin), is one of the commercial mollusks off the Atlantic coast of the United States and Canada. It is harvested over its entire range, which extends from the Gulf of St. Lawrence (Posgay, 1957) to south-southeast of Cape Hatteras, N.C. (Porter, 1974). Historically, the largest harvests by U.S. fishermen have been from Georges Bank with smaller harvests from the Gulf of Maine, Cape Cod Bay, and the Middle Atlantic Shelf, but since 1975, more than 60 percent of the total U.S. scallop harvest has been from the latter area. Canadian fishermen harvest sea scallops from Georges Bank northward to the Gulf of St. Lawrence. In 1976, 8,712 metric tons of sea scallop meats were landed by U.S. fishermen (ICNAF, 1977), a quantity more than three times larger than that landed in any year between 1969 and 1974 (Fig. 1); the Canadian landings were a record high.

The Woods Hole Laboratory of the Northeast Fisheries Center has studied sea scallop stocks on Georges Bank regularly since the late 1950's. Population distribution, length and age composition, and growth rates have been monitored. The St. Andrews Biological Station, New Brunswick, Canada, has also surveyed sea scallops on Georges Bank (Caddy, 1975; pers. commun.). An early survey of sea scallops on the Middle Atlantic Shelf was made by the U.S. fisheries schooner *Grampus* in 1913 (Anonymous, 1914); a later one by the RV *Delaware* in 1960 (Merrill, 1962).

The objectives of the 1975 surveys were to make observations on the distribution and abundance, spawning season, and length frequency of sea scallops on Georges Bank and the Middle Atlantic Shelf.

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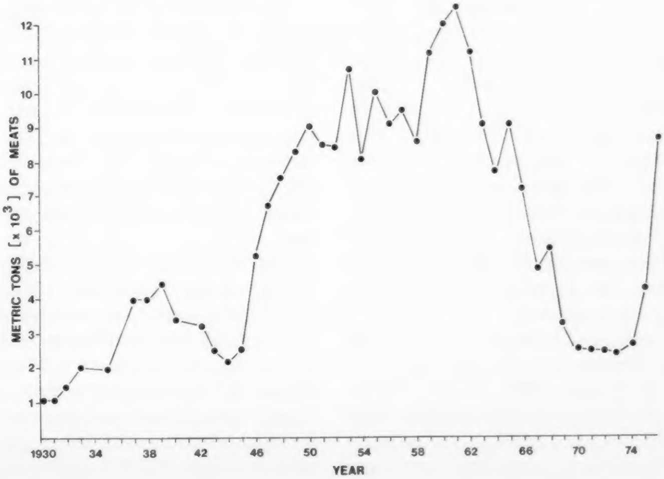
## MATERIALS AND METHODS

Two sea scallop surveys on the RV *Albatross IV* extended from Georges Bank southward to Cape Hatteras in 1975. A standard 10-foot (3.05-m) sea scallop dredge with a bag of 2-inch (5.08-cm) rings was used. Tows were of 15-minute duration at 6.3 km/hour (3.5 knots). Scallop numbers, condition of the gonads, and shell lengths were recorded. Gonadal condition was determined using criteria established by Posgay and Norman (1958). Gonads

Figure 1.—Historical landings of sea scallops by U.S. fishermen. Sources: Lyles (1969); Fishery Statistics of the United States (1968-73); Fisheries of the United States (1974-75); ICNAF (1977).



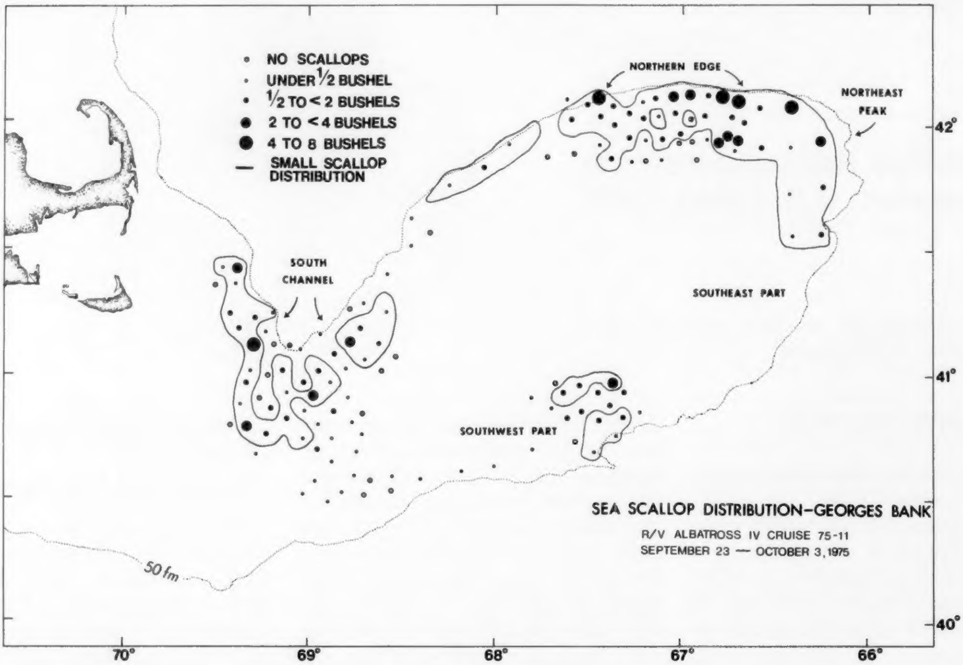



Figure 2.—Station pattern and sea scallop distribution and abundance (bushels per 15-minute tow) on selected areas of Georges Bank, 23 September to 3 October 1975. Solid lines indicate probable limits of distribution of small scallops, mostly the 1972 year class.

were divided into those spawned and not spawned. Between 42 and 130 males and 51 to 116 females were examined at five stations over the surveyed area. The depths of the stations were near the mean depth for scallops on Georges Bank and the Middle Atlantic Shelf. Temperature data were collected from bathythermographic casts.

A total of 144 stations, mostly spaced about 8 km apart, was sampled on Georges Bank between 23 September and 3 October 1975. Station depths ranged from 22 to 183 m. Stations were in three sections of known scallop abundance: 1) Northern Edge and Northeast Peak, 2) Southwest Part, and 3) South Channel. A survey of the southeast part of Georges Bank was planned, but hurricane threats limited sampling operations.

A total of 99 stations was sampled on the Middle Atlantic Shelf between 7 and 16 August 1975. Station depths ranged from 26 to 148 m. Stations were spaced along and among eight transects that were nearly perpendicular to shore and equidistant from each other between eastern Long Island, N.Y., and Cape Hatteras, N.C.

## RESULTS

### Georges Bank

#### *Distribution and Abundance*

The distribution of sea scallops surveyed on Georges Bank is shown in Figure 2. Scallops were taken at 118 of the 144 stations, on bottoms consisting of various combinations of sand, gravel, rocks, boulders, and shells of dead mollusks—mostly surf clam, *Spisula solidissima* (Dillwyn); ocean quahog, *Artica islandica* (Linné); and sea scallop.

The abundance of sea scallops on Georges Bank is indicated in Figure 2. The largest collections were made on the Northern Edge and Northeast Peak, where stations averaged 1.2 bushels (range, 0-7.5 bushels) (1 bushel = 35.2 liters) of scallops per tow. In the Southwest Part, stations averaged 0.75 bushels (range, 0-2.0 bushels) of scallops per tow. In the South Channel, stations averaged 0.4 bushels (range 0-4.0 bushels) of scallops per tow.

Solid lines encircling areas of distribution of small scallops, most of which belonged to the 1972 year class, are also shown on Figure 2. Small scallops were taken at about two-thirds of stations on the Northern Edge, at all the Northeast Peak stations, and at about one-third of stations in the Southwest Part and the South Channel.

Scallops were collected at depths that ranged from 37 to 100 m (two scallops were caught at 183 m); mean depth for scallops was about 68 m:

| Depth range (m) | Scallops (percent) |
|---|---|
| 37-50 | 13 |
| 50-75 | 54 |
| 76-100 | 33 |

#### *Spawning Season*

The gonadal condition of the scallops indicated that spawning was in progress in late September and early October. The percentages of scallops that had

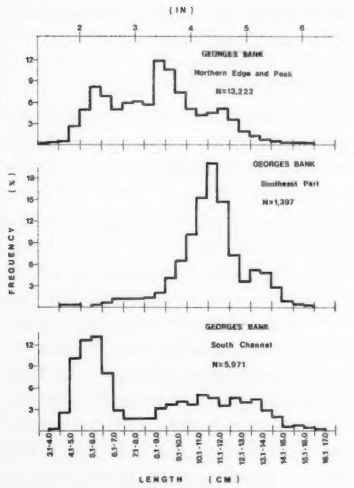



Figure 3.—Length-frequency histograms of sea scallops from three sections of Georges Bank. Number of scallops measured is indicated.

spawned and the bottom temperatures by section were:

| Section | Percent spawned Males | Percent spawned Females | Depth (m) | Bottom temperature (°C) |
|---|---|---|---|---|
| Northern edge | 60.2 | 36.6 | 68 | 11.2 |
| Southwest part | 2.8 | 10.4 | 68 | 10.0 |
| South channel | 50.0 | 41.2 | 60 | 9.0 |

Collectively, the samples contained 216 males and 219 females, a 1:1 sex ratio.

*Length Frequency*

Figure 3 shows the length-frequency histograms of sea scallops within the three sampled sections of Georges Bank. A significant number of scallops ranged between 3.0 and 7.0 cm long; most represented the 1972 year class. Within the surveyed sections, the approximate percentages of scallops between 3.0 and 7.0 cm were: Northern Edge and Northeast Peak, 28 percent; Southwest Part, 2 percent; and South Channel, 50 percent.

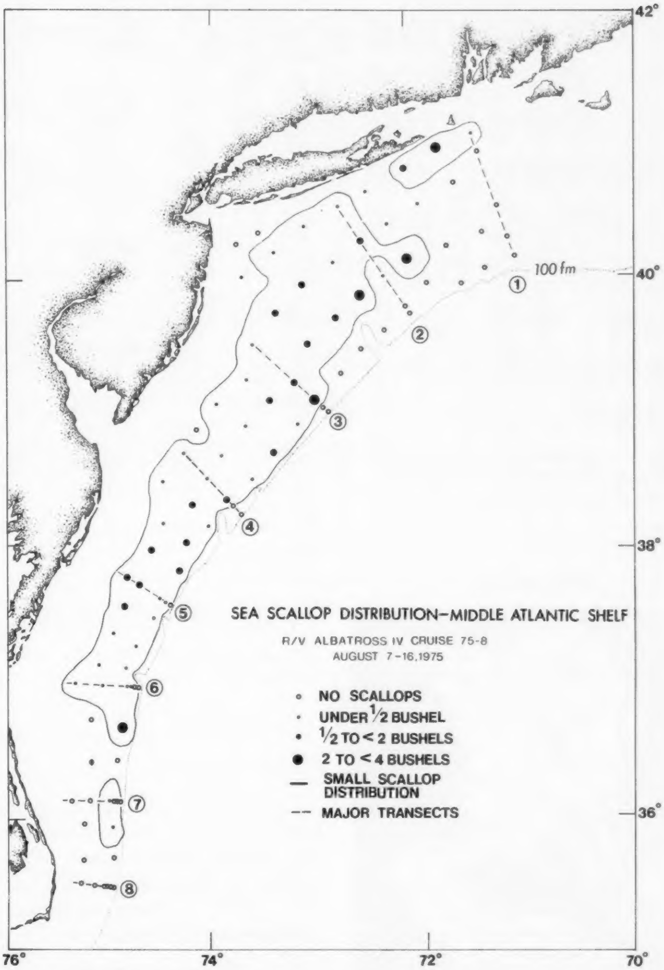



Figure 4.—Station pattern and sea scallop distribution and abundance (bushels per 15-minute tow) on the Middle Atlantic Shelf, 7-16 August 1975. Solid lines indicate probable limits of distribution of small scallops, mostly the 1972 year class.

## Middle Atlantic Shelf

*Distribution and Abundance*

The distribution of sea scallops surveyed on the Middle Atlantic Shelf is shown in Figure 4. Scallops were taken at 57 of the 99 stations, on bottoms consisting of sand and sand-gravel. Scallops were distributed closer to shore at the northern end than at the southern end of the shelf. The southernmost collection of scallops was taken off Oregon Inlet, N.C. (lat. 35°53′N, long. 74°55′W).

The abundance of sea scallops on the Middle Atlantic Shelf is indicated in Figure 4. The largest collections were made south of Long Island and east of New Jersey where six stations had between 1.0 and 2.0 bushels of scallops per tow. The largest collection, 2.5 bushels, consisted mostly of individuals ranging from 3.0 to 8.0 centimeters long, and was offshore of the Virginia-North Carolina border.

Small scallops that belonged mostly to the 1972 year class were taken at half the stations; their distribution is shown by solid lines in Figure 4. Small scallops were distributed over nearly the full width of the sampling area from mid-Long Island to the mouth of Chesapeake Bay. In addition, they were also found in two other discrete areas; one off the southeastern tip of Long Island and another off Albemarle Sound, N.C.

Scallops were collected at depths that

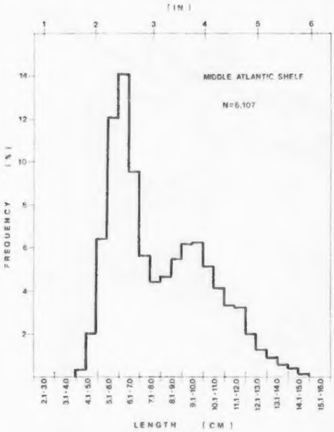



Figure 5.—Length-frequency histogram of sea scallops from the Middle Atlantic Shelf. Number of scallops measured is indicated.

Sorting the catch.

ranged from 31 to 80 m (one scallop was collected at 110 m), mean depth for scallops was about 55 m:

| Depth range (m) | Scallops (percent) |
|---|---|
| 31-50 | 24.8 |
| 51-75 | 75.0 |
| 76-80 | 0.2 |

*Spawning Season*

The gonadal condition of the scallops indicated spawning during mid-August. Judging from the condition of some flaccid gonads, it appeared that spawning began during July. The percentages of scallops that had spawned and the bottom temperatures were:

| Section | Percent spawned | | Depth (m) | Bottom temper-ature (°C) |
|---|---|---|---|---|
| | Males | Females | | |
| Off southeastern Long Island | 60.3 | 54.3 | 64 | 6.5 |
| Off Chincoteague Bay | 67.5 | 74.5 | 37 | 11.0 |

Collectively, the samples contained 236 males and 163 females, a 1.4 to 1 sex ratio.

*Length Frequency*

Figure 5 shows the length-frequency histogram of sea scallops from the entire Middle Atlantic Shelf. About 50 percent of the scallops were between 3.0 and 7.0 cm long, and most represented the 1972 year class.

## DISCUSSION

### Distribution and Abundance

Sea scallops were collected on the traditional commercial fishing grounds on Georges Bank and the Middle Atlantic Shelf. Scallops were found in commercial quantities nearly 85 km farther south (lat. 35°33′N, long. 74°55′W) than previously by Merrill (1962) on the Middle Atlantic Shelf.

Mean depth for scallops on Georges Bank, about 68 m, was 13 m deeper than that on the Middle Atlantic Shelf, about 55 m.

The extensive distribution of the 1972 year class of scallops is likely to disperse the commercial fishing effort over the Bank and the Shelf. The scarcity of older year classes may lead to the 1972 year class being overfished.

### Spawning Season

The time of sea scallop spawning has been infrequently documented. Previous records include: Georges Bank, September (Posgay and Norman, 1958); Cape Cod Bay, September and October (Posgay, 1950); New Hampshire, September (Culliney, 1974); Maine, August (Drew, 1906); and Bay of Fundy, August and September (Stevenson, 1936; Dickie[1]). No records exist for scallop spawning on the Middle Atlantic Shelf. The current observations revealed that scallops were spawning off Virginia and Long Island during August, and on Georges Bank during late September and early October. Spawning had not progressed as far on the Bank then as it had on the Shelf during August. Probably, scallops begin spawning on the Middle Atlantic Shelf during July, and a progression of spawning ensues northeastward onto Georges Bank as the season advances.

### Length Frequency and Recent Landings

There was excellent recruitment to the sea scallop population on Georges Bank and the Middle Atlantic Shelf, primarily due to the exceptionally abundant 1972 year class. The scallops became large enough for harvest in 1975, 1976, and 1977 and have led to significant increases in landings during those years. United States sea scallop landings doubled from 4,422 metric tons (meats) in 1975 to 8,712 metric tons in 1976 (Fig. 1). Similarly, Canadian landings from the Georges Bank fishery increased from 7,387 to 8,564 metric tons between 1975 and 1976 (ICNAF, 1977); the 1976 scallop harvest was the highest in the history of the Canadian fishery. Total scallop landings (United States and Canada) in 1976 from Georges Bank and the Middle Atlantic Shelf were 18,371 metric

[1]Dickie, L. M. 1953. Fluctuations in abundance of the giant scallop, *Placopecten magellanicus* (Gmelin), in the Digby area of the Bay of Fundy. Unpubl. rep. Fish. Res. Board Can. Manuscr. Rep., Biol. Ser., No. 526.

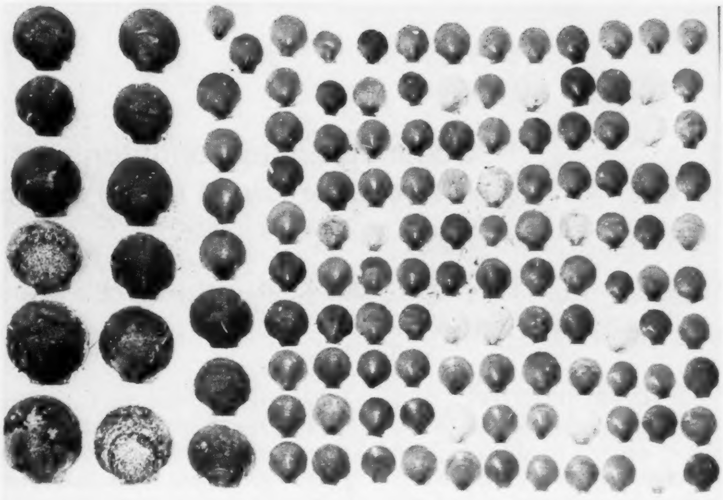
tons, a 56 percent increase over the total 1975 catch of 11,809 metric tons (ICNAF, 1977). Preliminary analysis of U.S. scallop landings during the first several months of 1977 suggests that the total U.S. landings for the year may be substantially greater than those of 1976.

## CONCLUSIONS

Commercial scallop length frequency data (both United States and Canada) indicate that the present scallop fisheries are dependent mostly on the 1972 year class. The high abundance exhibited by the 1972 year class does not, in itself, insure that the scallop stock will not be overfished. Indeed, it is possible that growth overfishing (the removal of scallops before they have attained their maximum growth potential, i.e., yield per recruit) may have already transpired. From the little knowledge available of stock-recruitment relationships for sea scallop populations and given the characteristic irregularity of recruitment, it appears desirable to estimate the size of an adult spawning stock that is large enough for providing adequate recruitment in the future and then regulate for preserving it, in order that a viable fishery will be maintained. Management alternatives to reach this objective are currently being considered by the newly established Regional Fishery Management Councils.


## ACKNOWLEDGMENT

We wish to thank J. Arthur Posgay for reviewing the manuscript.

The entire catch at a sampling station on the Middle Atlantic Shelf. 1972 recruits are on the left, older scallops on the right.

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# Oceanographic Conditions off California to Vancouver Island in the Summer of 1977

W. JAMES INGRAHAM, Jr. and CUTHBERT M. LOVE

## INTRODUCTION

An extensive United States-Poland cooperative fishing-oceanographic survey along the west coast of the United States (California-Oregon-Washington) and along Vancouver Island, Britsh Columbia, was carried out from 12 August to 22 September 1977. The personnel were from the NMFS Northwest and Alaska Fisheries Center (NWAFC) in Seattle, Wash., and from the Polish Sea Fisheries Institute (SFI) in Gdynia.

Daily fishing operations were carried out aboard the NOAA Research Vessel *Miller Freeman* and the Polish Research Vessel *Profesor Siedlecki* (Fig. 1) to assess the biomass of rockfish, genus *Sebastes*, and Pacific hake, *Merluccius productus*, using comparable hydroacoustic and trawling techniques. Each night, special fishing studies and expendable bathythermograph releases were carried out aboard the *Miller Freeman*. Oceanographic data (Nansen bottle casts, salinity-temperature-oxygen-depth sensor lowerings, and plankton samples) were obtained aboard the *Profesor Siedlecki*.

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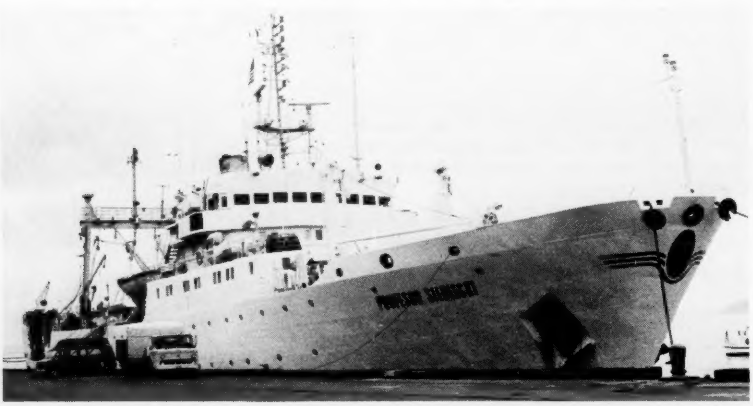
This report gives a preliminary assessment of the physical-chemical data obtained aboard the *Profesor Siedlecki*. As the vessel proceeded northward from lat. 39°N along the California coast to Vancouver Island following a series of zig-zag cruise tracks across the continental shelf, 23 lines of oceanographic stations normal to the coast were conducted at roughly 50-km (30-mile) intervals (Fig. 2A). These 163 stations provide the most complete and quasi-synoptic data ever obtained in this area.

Because there was time for only 5-7 oceanographic stations each night, these were positioned near the 75, 100, 150 200, 500, and 1,000 m isobaths to investigate conditions along the upper continental slope as well as over the shelf. Oceanographic data were tabulated aboard ship and are available at NWAFC and at SFI. Exhaustive descriptive analyses will be forthcoming from SFI personnel. C. M. Love served as Field Party Chief of the U.S. research team board the *Profesor Seidlecki* and assisted in the oceanographic studies.

Figure 1.—The Polish research vessel *Profesor Siedlecki* at Seattle, Wash.



## COASTAL CURRENTS

Geostrophic currents derived from geopotential topographies provide an indication of flow relative to a selected reference level. Although a deep level (preferably one at which no flow occurs) is desirable, it is becoming increasingly apparent that predominant surface flow patterns can be obtained by this method even though reference levels of 100 to several hundred decibars (db) are used.

Surface currents referred to 100 db (approximately 100 m) (Fig. 2B) were similar to those referred to 500 db, but the choice of the shallower depth provides more detail of flow over a wider expanse of the shelf. Surface flow was generally southward all along the coast, except for sporadic eddies and a fairly

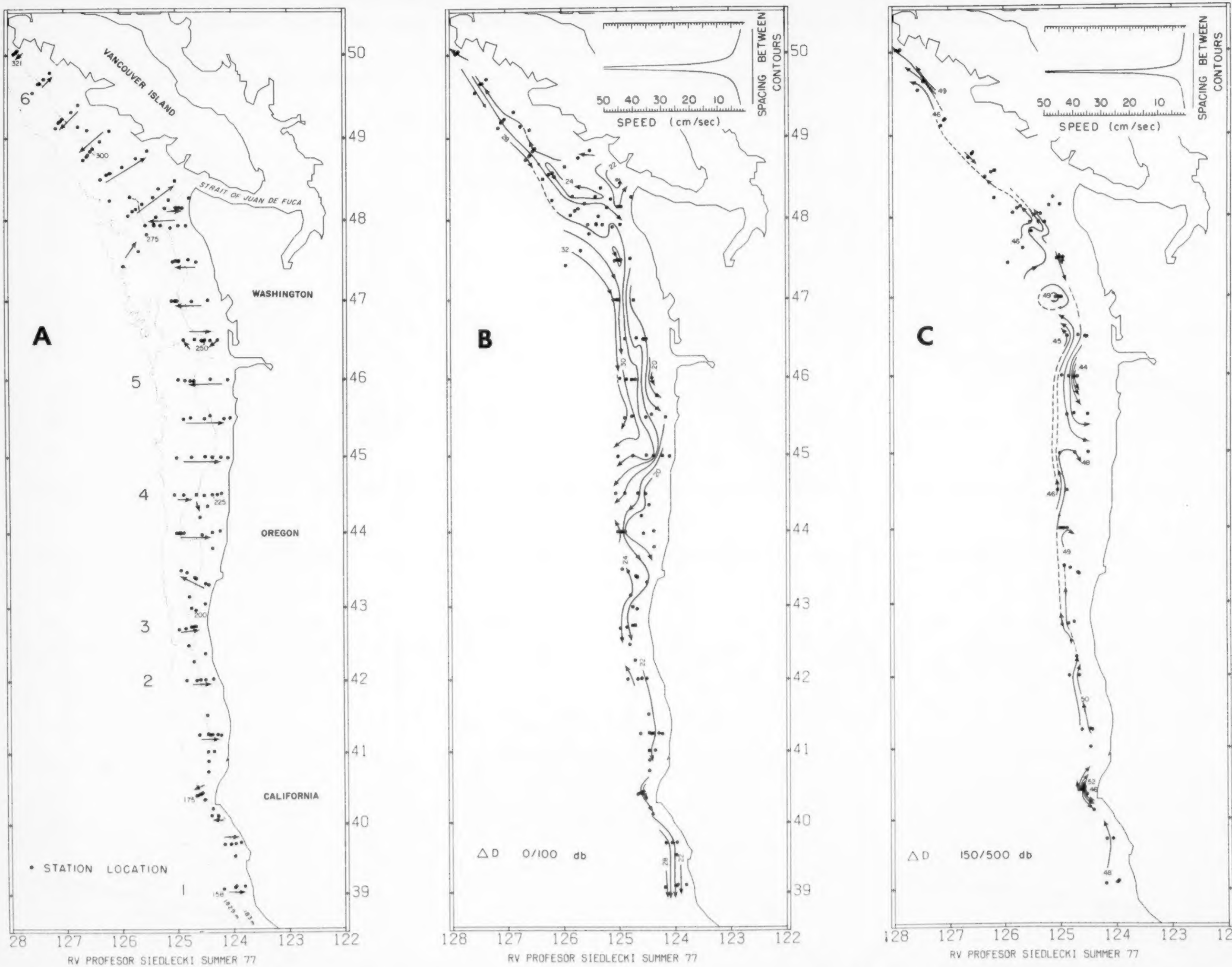



Figure 2.—Track of the research vessel *Profesor Siedlecki* and stations where data on coastal currents were obtained. Large numbers refer to locations of vertical sections in Figure 4.

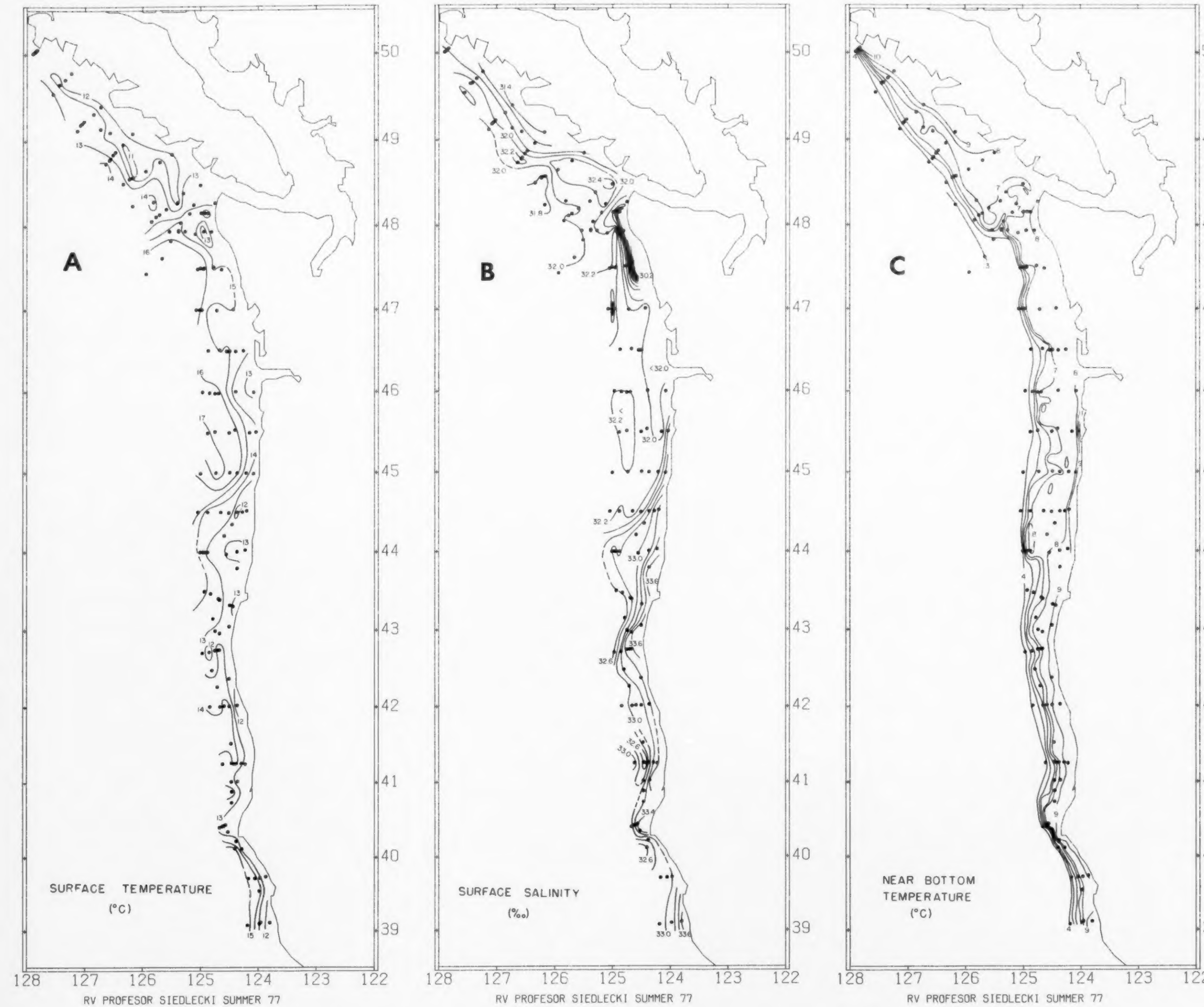



Figure 3.—Track of the research vessel *Profesor Siedlecki* and stations where temperature and salinity data were obtained.

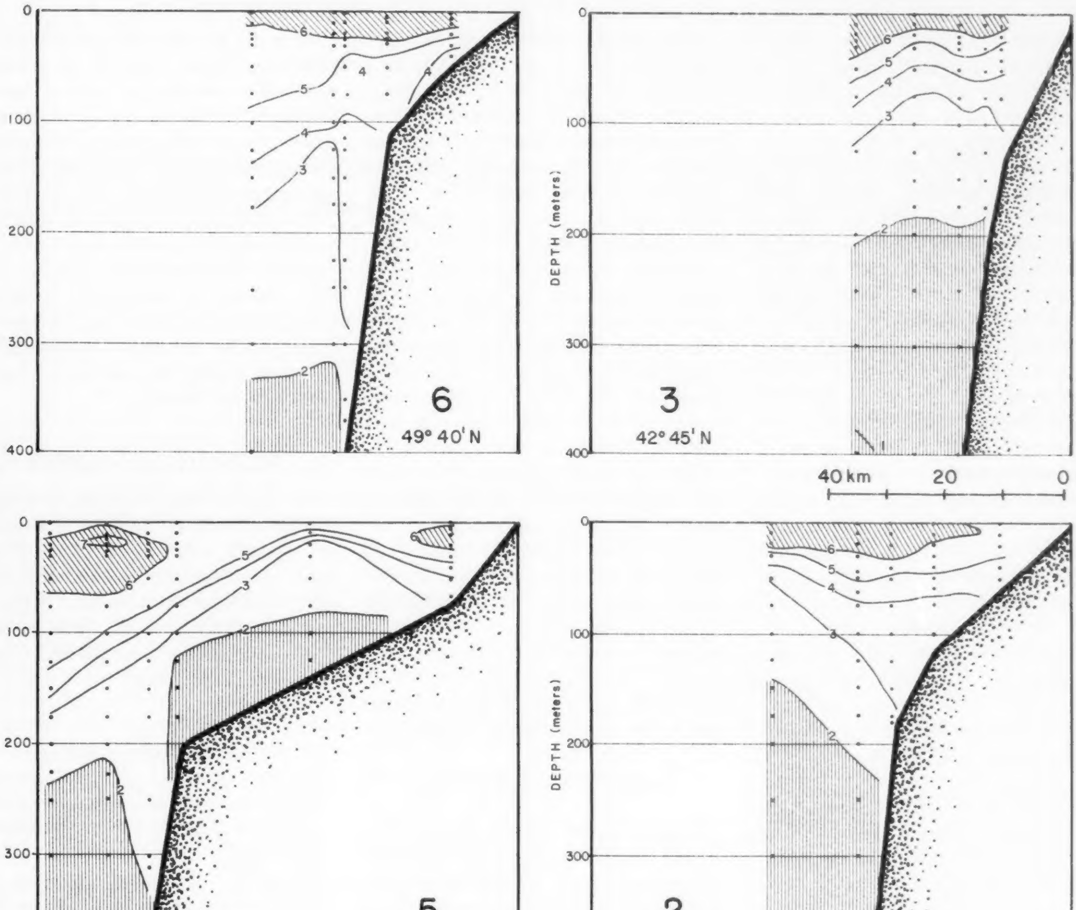



Figure 4.—Distributions of dissolved oxygen (milliliters/liter) at latitudes shown.

consistent northward flow inshore along the west coast of Vancouver Island. This flow is fairly characteristic of summer conditions along this coast.

However, the flow at 150 db (computed relative to 500 db) was generally northward except in the vicinity of the Columbia River where an inshore southward flow occurred. This northward countercurrent at depth has been denoted as the California Undercurrent (Dodimead et al., 1963; Favorite et al., 1976). The apparent discontinuities in this flow along the shelf edge are believed to be due to inadequacies in the method and the paucity of data, rather than in the flow itself. The existence in the coastal regime of a northward surface flow during winter and a subsequent reversal in spring and summer has been indicated by numerous drift bottle experiments conducted in the past (Reid, 1960; Burt and Wyatt, 1964; and Ingraham and Hastings, 1976); however, except for limited observations off the Washington coast (Reed and Halpern, 1976), we believe that these present data are the first convincing evidence of a northward flow at depth during summer over such an extensive portion of the west coast of the United States. The effects of this flow on ichthyoplankton and adult fish have yet to be investigated.

## TEMPERATURE AND SALINITY

Surface temperatures (Fig. 3A) unavoidably reflect some time-change effects because of the cruise duration, but it is apparent that inshore surface temperatures were 3°-4°C lower than those near and seaward of the shelf edge. This generally reflects the effects of coastal upwelling characteristic of the summer period; however, winds during the cruise period were generally light and intense upwelling probably did not occur. The low temperatures along Vancouver Island are attributed to runoff and to vertical mixing in the Strait of Juan de Fuca.

Low surface salinities in this area generally reflect river runoff, and high salinities indicate areas of upwelling. The low salinities (<32‰) along Vancouver Island and Washington are due to river runoff, whereas the high salinities (<33‰) south of lat. 46°N clearly indicate upwelling extended at least as far south as lat. 39°N (Fig. 3B).

Bottom temperatures (Fig. 3C) reflect a general uniformity along isobaths, the inshore (50-100 m depth) temperature change along the entire coastline being only 2°C (7°-9°C). Conversely, seaward temperature gradients of 0.4°C/km occurred frequently. Bottom salinities generally reflect the same concentration along shelf and across shelf waters; thus, it appears that neither temperature nor salinity are environmental barriers to alongshore movements of fish stocks at constant depth levels, nor any rationale for explaining changes in abundance that occur under these conditions along the coast. However, the distributions of dissolved oxygen reflect marked changes in environmental conditions.

## DISSOLVED OXYGEN

Changes in the distributions of dissolved oxygen values along the coast are reflected in six vertical sections at locations indicated in Figure 4. Near the surface occasional inversions of oxygen concentration occurred with local maxima at about 10 m depth that are probably due to high primary (plant) production; in some instances, supersaturation occurred due to the high production. However, at depth, marked fluctuations in concentrations occurred, particularly near the bottom. At lat. 49°40′N, values greater than 3 ml/liter were present as deep as 300 m; whereas, at lat. 46°N and long. 44°30′W values less than 2 ml/liter occurred as shallow as 100 m depth; and, at lat. 39°43′N values of 2 ml/liter occurred below 400 m.

It is not known what percentage of saturation values represent an undesirable environment or even a lower threshold for Pacific hake or other fish stocks. Such studies should be undertaken. Further, it is also apparent that such large variations in dissolved oxygen values may also affect the distribution of forage organisms and thus indirectly the distribution and abundance of fish. Results of studies of resource/environmental relations will be forthcoming as the extensive masses of data collected during the survey are compiled and correlated.

## ACKNOWLEDGMENTS

We thank Felix Favorite, NWAFC Resource Ecology Studies Coordinator, and the following *Profesor Siedlecki* oceanographers—Andrzej Furtak, Andrzej Majewics, Bogdan Szpiganowicz, Ryszard Gurbiel, and Wojcieck Sztajnduchert—for assistance and cooperation.

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MFR PAPER 1285

# The Pacific Northwest Commercial Fishery for American Shad

NORMAN B. PARKS

The American shad, *Alosa sapidissima,* is similar in appearance to other herring-like fishes and, with lengths up to 30 inches (76 cm), is the largest member of the herring family (Clupeidae) in North America (Fig. 1). It is an anadromous fish which in the spring ascends rivers and streams to spawn. The species is native to the North Atlantic Ocean and coasts of North America from the St. Lawrence River region southward and westward into the Gulf of Mexico. The shad is one of the best known fishes of the U.S. east coast and a target of commercial and recreational fishermen (Cheek, 1968). It was introduced to the west coast during the latter part of the nineteenth century and soon became well established as a species of commercial interest. This report describes the introduction of the species to the west coast; it also reviews the commercial fishery in Oregon, Washington, and British Columbia.

## INTRODUCTION TO THE WEST COAST

American shad were first introduced from the east coast into California's Sacramento River in 1871. In 1885 and 1886 a total of 910,000 shad fry were planted in the northwest's Columbia, Snake, and Willamette Rivers. No further plantings have been made, so the successful establishment of shad in rivers of the Pacific Northwest must be attributed to the 1885-86 plants and to whatever adults migrated into the rivers from the populations of the Sacramento River and other locations south of the Columbia (Craig and Hacker, 1940).

In 1891 mature shad were first taken in the Fraser River in British Columbia and the Stikine River in southeastern Alaska, according to Welander (1940). He stated that the spread and the increase of the shad along the Pacific coast of North America has been one of the most remarkable in all cases of introduced species. Shad now range from the Todos Santos Bay, Baja California, to Cook Inlet and Kodiak Island, Alaska (Fig. 2) according to Hart (1973).

## HISTORY OF THE FISHERY

The success of attempts to establish shad in the Pacific Northwest was indeed remarkable. First commercial landings of shad were reported from the Columbia River in 1889, and the shad's abundance had depressed the market

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value as early as 1893 (Craig and Hacker, 1940). The average annual commercial landings of shad in the Columbia River districts of Oregon and Washington are shown in Table 1. Catches were at their highest levels from 1926 to 1930 and in 1946 and 1947. Between 1 and 1.5 million pounds (453,515 and 680,272 kg) were taken in each of these years. In spite of the fact that there has been enough shad

Figure 2.—West coast range of American shad.

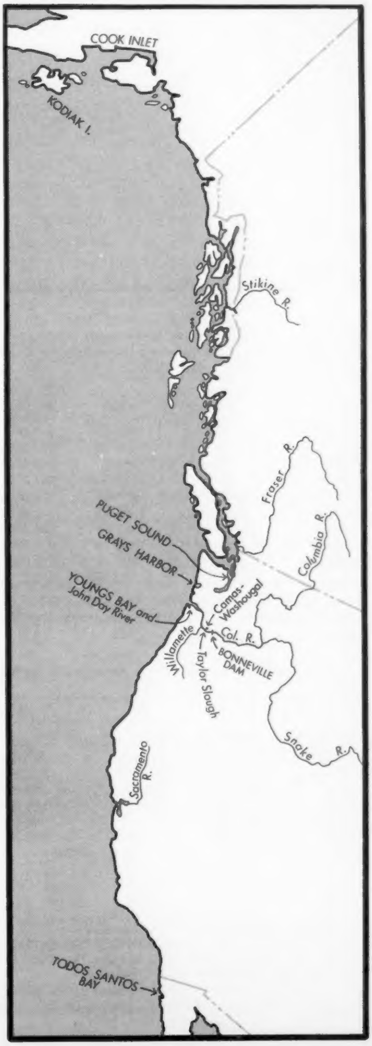
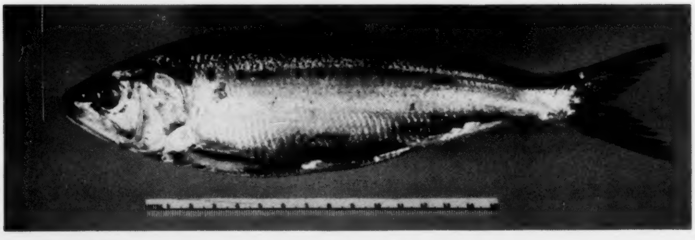



Figure 1.—American shad, *Alosa sapidissima.*



in the Columbia River to support a larger fishery, the catches of shad were rather incidental and supplemental to the Pacific salmon, (*Oncorhynchus* spp.) fisheries until the mid-1940's. The main reason was that the run of shad coincided with the run of sockeye salmon, *O. nerka*, and summer chinook salmon, *O. tshawytscha*, which have higher market values than shad. Average commercial shad catches of 218,000 pounds (98,866 kg) in the Columbia River during the last 5 years (1971-75) were less than half those of the previous 10 years.

Figure 3.—Location of five western Oregon rivers with commercial fisheries for shad (from Mullen, see footnote 4).


**Table 1.—Average annual commercial landings (in pounds) of shad in the Columbia River districts of Oregon and Washington, 1889-1975[1].**

| Years | Avg. annual landings[2] | Years | Avg. annual landings |
|---|---|---|---|
| 1889-90 | 68,000 | 1931-35 | 483,000 |
| 1891-92 | 170,000 | 1936-40 | 295,000 |
| 1896-1900 | 572,000 | 1941-45 | 545,000 |
| 1902-05 | 189,000 | 1946-50 | 841,000 |
| 1906-10 | 357,000 | 1951-55 | 311,000 |
| 1915 | 581,000 | 1956-60 | 178,000 |
| 1923 | 334,000 | 1961-65 | 563,000 |
| 1925 | 665,000 | 1966-70 | 476,000 |
| 1926-30 | 1,245,000 | 1971-75 | 218,000 |

[1]Sources: Pruter (1972) for 1889-1965; for 1966-75 from Oreg. Dep. Fish Wildl. and Wash. Dep. Fish. (1976).
[2]Landings prior to 1925 are known only for the indicated years.

A commercial fishery for shad also exists in the same five rivers along the Oregon coast where striped bass, *Morone saxatilis*, have been taken commercially (Fig. 3). These are the Siuslaw, Smith, Umpqua, Coos, and Coquille Rivers. Mature shad were first taken in rivers in southern Oregon in 1882 (Welander, 1940). The commercial catch data for shad in these rivers began in 1923 when a total of 182,000 pounds (82,540 kg) was landed (Table 2). The largest catches occurred between 1945 and 1951 when 789,000-1,339,000 pounds (357,823 to 616,326 kg) were landed. Average commercial shad catches in these rivers of 326,339 pounds (148,000 kg) during 1971-74 were well below average for the previous 10 years. Only during the 1956-60 period were the average catches lower than those of the 1971-74 period.

Small incidental catches of shad are made in Oregon and Wasington coastal waters and rivers, in Grays Harbor, and in Puget Sound. These incidental catches generally range from a few pounds to a few thousand pounds and are taken primarily by gillnets in the rivers and harbors and by otter trawls in coastal waters and in Puget Sound.

**Table 3.—Average annual commercial landings in pounds of shad in the Fraser River district of British Columbia, 1917-73[1].**

| Years | Avg. annual landings | Years | Avg. annual landings |
|---|---|---|---|
| 1917-20 | 8,200 | 1946-50 | 0 |
| 1921-25 | 1,060 | 1951-55 | 245,400 |
| 1926-30 | 700 | 1956-60 | 161,800 |
| 1931-35 | 740 | 1961-65 | 56,200 |
| 1936-40 | 0 | 1966-70 | 47,800 |
| 1941-45 | 340 | 1971-73 | 44,000 |

[1]Source: Fishery Statistics of Canada—Canada Summaries.

**Table 2.—Average commercial landings of shad from Oregon coastal streams, 1923-74.[1]**

| | Average landings in pounds | | | | | |
|---|---|---|---|---|---|---|
| Years | Siuslaw | Smith | Umpqua | Coos | Coquille | Total |
| 1923-25 | 14,683 | [2]349,981 | | 51,582 | 178 | 416,424 |
| 1926-30 | 20,353 | 452,855 | | 88,437 | 849 | 562,494 |
| 1931-35 | 41,240 | 293,696 | | 101,152 | 10,029 | 446,117 |
| 1936-40 | 34,022 | 326,080 | | 75,955 | 10,109 | 446,166 |
| 1941-45 | 51,901 | 396,329 | | 196,886 | 10,211 | 655,327 |
| 1946-50 | 65,999 | 674,944 | | 272,743 | 4,294 | 1,017,980 |
| 1951-55 | 34,185 | 179,061 | 239,679 | 142,330 | 14,960 | 610,215 |
| 1956-60 | 24,082 | 51,631 | 185,051 | 38,490 | 11,772 | 311,026 |
| 1961-65 | 23,644 | 45,829 | 383,326 | 90,085 | 32,302 | 575,186 |
| 1966-70 | 10,861 | 62,277 | 350,547 | 54,557 | 16,231 | 494,473 |
| 1971-74[3] | 14,261 | 24,118 | 221,443 | 58,451 | 8,066 | 326,339 |

[1]Source: Mullen, R. E. 1972. Ecology of shad and striped bass in coastal rivers and estuaries. Fish. Comm. Oreg., Manage. Res. Div., Public Law 89-304 Proj., Annu. Rep. 1 July 1971 to 30 June 1972, 31 p. Typescript.
[2]Smith and Umpqua Rivers combined through 1950.
[3]Pers. commun., Jerry MacLeod, Aquatic Biologist, Oreg. Dep. Fish Wildl., Coos Bay, Oreg., 12 August 1976.

In addition, shad have been taken commercially in the Fraser River in British Columbia (Table 3).

## PRODUCTS

Although shad are regarded as a great delicacy on the east coast of the United States and demand a high price in the markets of that region, they have never been favorably received as a food fish by the people of the west coast (Craig and Hacker, 1940). In recent years shad have been harvested primarily for the eggs or roe of the females as there is only limited demand for shad flesh, although it is considered quite palatable by some despite a profusion of small bones[1]. Roe with the highest market value consists of ovaries containing all immature opaque eggs (Hasselman, 1966). Small quantities are sometimes frozen whole. However, the carcasses of females have often been sold for cat or mink food, for reduction, or for use as crab bait, while the males are sometimes returned to the water at the time of capture. Recent prices in the Columbia River shad fishery are approximately 15 cents per pound for round roe shad and from 4 to 10 cents per pound for males, depending upon the quality. Prices for male shad have been as low as 1½ cents per pound during some past years[2].

## DESCRIPTION OF THE FISHERY

### Areas

In the Columbia River, shad are abundant in all of the lower portions of the river in season. The gillnet fishery normally extends about 140 miles upstream from the mouth of the Columbia River to a commercial fishing boundary 5 miles below Bonneville Dam (Hasselman, 1966). The Camas-Washougal shad fishing areas have often contributed from 30 to 50 percent of the total catch. Since 1969 small new shad fisheries have been developed in John Day River, Taylor Slough, and Youngs

[1]Young, F. 1970. Biology of Columbia River shad and the development of selective commercial fishing gear. Fish. Comm. Oreg., Res. Div., Prog. Rep., Jan. 1969-Sept. 1970, 12 p. Typescript.
[2]Pers. commun., Duncan K. Law, Assoc. Professor, Oreg. State Univ., Dep. Food Sci. Technol., Seafoods Lab., Astoria, Oreg., 13 August 1976.

Bay. These fisheries were initiated in an attempt to selectively harvest shad without endangering runs of summer chinook salmon[3].

In the Siuslaw, Smith, Umpqua, Coos, and Coquille Rivers in Oregon, most commercial fishing for shad and for striped bass is conducted in the tidal portion of each river, although nets may legally be used in bays[4].

In the Smith and Umpqua Rivers, shad are only taken (in any numbers) within about 15 miles of the rivers' mouths, although the commercial fishery is permitted to operate some distance farther up river (Gharrett, 1950).

### Seasons, Gear, and Regulations

Shad are present in the Columbia River beginning in late April and occur mainly as an incidental catch during the spring and summer salmon seasons. Peak catches are usually made at the time of the spawning migration which occurs during the month of June. Roe rather than flesh is the target of most fishermen. Consequently, though many shad remain in the river after 1 July, the fact that spawning has already occurred and roe is no longer available ends the fishery at about this time[5].

Both season and gear restrictions are primarily designed to protect the run of summer chinook—in the same area and at the same time as peak shad abundance—in the Columbia River. Fishermen in the main Columbia River have been unsuccessful in selectively harvesting shad without having a high incidental catch of summer chinook. As a result, a limited shad season is allowed each year in the main Columbia River after the peak of the summer chinook run passes beyond the shad fishing area.

In the past, traps, seines, and fish wheels have all been used to catch shad in the Columbia River, but only gillnets are now used commercially (Cleaver, 1951). Two types of gillnets are used. These include both set-nets and drift-nets. More recently the gear has been restricted to shad nets with a required maximum breaking strength to allow salmon to break free.

In the shad fishery on the Siuslaw, Smith, Umpqua, Coos, and Coquille Rivers, there have been no recent changes in the commercial fishing regulations. The major regulations are the same as those which existed for striped bass and consist of fishing deadlines (or boundaries), gear type, mesh size, and seasonal restrictions by river. Gear and season restrictions are primarily designed to protect spring chinook in the early spring and steelhead trout, *Salmo gairdneri*, in the summer. Each fisherman in the set-net fishery is allowed to fish six nets while drift-net fishermen are restricted to one net. The fishermen are required to sell all of their catch to a licensed wholesale fish buyer (see footnote 4). In these Oregon coastal rivers, as in the Columbia, the shad are caught in the late spring and early summer when they enter the rivers to spawn.

## CURRENT TRENDS AND FUTURE STATUS

The history of the gillnet fisheries for shad has demonstrated that commercial quantities of shad cannot be harvested with gillnets in Pacific Northwest rivers when salmon are abundant without a large catch of salmon being taken. If methods could be developed to selectively capture shad without harming the salmon runs, the shad fishery could be expanded and the catch increased considerably. New drift-net fisheries have been developed in John Day River, Taylor Slough, and Youngs Bay in an attempt to find ways to selectively harvest shad. These fisheries have provided some additional harvests of the Columbia River shad resource without catching salmonids (see footnote 3).

The lack of demand for and the low value of shad products other than roe have also resulted in reduced fishing effort. The shad catches, therefore, are largely incidental to the salmon fisheries in the Columbia River and western Oregon rivers.

Since 1959 there have been dramatic increases in the shad counts over Bonneville Dam as shad extended their range far up the Columbia River and utilized the reservoirs as spawning and rearing areas. Annual shad runs to the Columbia River usually average in excess of 1 million fish, assuming that the lower river populations have not decreased greatly since the construction of Bonneville Dam. Of these an average of only 140,000 were caught commercially during the late 1960's, and most of those were from the upriver portion of the run (see footnote 1).

Studies by Walburg and Sykes (1957) on the Atlantic Coast streams indicate that a harvest of at least 50 percent is normal on intensively fished runs, while a maximum harvest of about 14 percent occurs in the Columbia River (see footnote 1).

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[3]Young, F. R. 1973. Shad fisheries in the John Day River (Clatsop County), Youngs Bay, and Taylor Slough. Fish. Comm. Oreg., Manage. Res. Div., Info. Rep. 73-1, 3 p.

[4]Mullen, R. E. 1972. Ecology of shad and striped bass in coastal rivers and estuaries. Fish. Comm. Oreg., Manage. Res. Div., Public Law 89-304 Proj., Annu. Rep. 1 July 1971 to 30 June 1972, 31 p. Typescript.

[5]State of Wash., Dep. Fish., Annu. Rep. 1947.


*MFR Paper 1285. From* Marine Fisheries Review, *Vol. 40, No. 2, February 1978. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*

## NMFS Recipients of Commerce Department Gold and Silver Medals Told

Four National Marine Fisheries Service employees were among 29 individual NOAA recipients of Gold and Silver Medals presented by Secretary of Commerce Juanita M. Kreps at a special ceremony in Washington, D.C. late last year.

Receiving Gold Medals were Robert L. Edwards, Director of the Northeast Fisheries Center, Woods Hole, Mass.; Richard C. Hennemuth, Director of the NEFC's Woods Hole Laboratory, Woods Hole, Mass.; and Richard L. McNeely, supervisory research electronic engineer at the Northwest and Alaska Fisheries Center, Seattle, Wash.

Receiving the Silver Medal was Howard S. Sears of the NWAFC's Auke Bay Fisheries Laboratory. Roland A. Finch, of NOAA's Office of Living Resources, Rockville, Md., also received the Silver Medal for his work in the creation of a national plan to rehabilitate the domestic fishing industry, meeting with leaders, developing goals, and preparing an "outline draft" which ultimately appeared as the National Plan for Fisheries in the United States.

Edwards was cited for his part in a successful management/scientific team that contributed to the shaping of national and international policies and programs in fisheries research and management. Together with Hennemuth, he was responsible for promoting an understanding of the marine ecosystems, including joint, cooperative research with foreign countries. A native of Philadelphia, Pa., Edwards earned his A.B. degree at Colgate University in 1947 and his master's and Ph.D. degrees at Harvard University by 1951. He entered Federal service in 1954.

Edwards

Hennemuth

McNeely

Hennemuth was honored along with Edwards for work in marine ecosystems. The citation calls the research ". . . the finest examples of joint and useful studies in the world." Born in Grand Forks, N.D., Hennemuth earned his B.S. degree in 1952 at Gustavus Adolphus College, St. Peter, Minn., and his M.S. degree in 1954 at State University of Iowa, Ames, Iowa. He has done graduate work at Harvard University, at the University of California at La Jolla, and at San Diego State College. He entered the Federal service in 1960.

McNeely was cited for his leadership and major contributions to the field of fishing gear technology, sampling system development, and conservation engineering. Until his return to the NWAFC in August 1977, he had been serving as leader of the Mortality Reduction Technology Task of the Porpoise/Tuna Interaction Program at the NMFS Southeast Fisheries Center, La Jolla, Calif. There, in 1972, he had been assigned the responsibility for developing and supervising the fishing gear phase of that program and he produced solutions to problems that had perplexed experienced fishermen for years, thus furthering porpoise conservation. A native of Huntington, W. Va., McNeely attended the University of Miami, Fla., and the University of Tennessee, Knoxville. He entered Federal service in 1955.

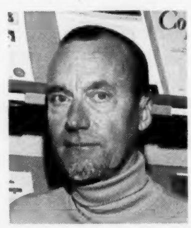
Sears was honored for aerial surveys of the biological and geological features of the Alaskan coast between the Bering Strait and Yakutat, a vital phase of the NOAA Outer Continental Shelf Energy Research Program in Alaska.

The highest honor that the Department of Commerce can bestow, the Gold Medal is awarded for rare and outstanding contributions of major significance to the Department, the Nation, or the world in science, technology, or administration; highly distinguished authorship; heroic action involving jeopardy of life; and outstanding leadership in the administration of a major program.

Silver Medals are awarded for contributions of unusual value to the Department in science, technology, or administration; outstanding skill or ability in the performance of duties which have resulted in program advancement; meritorious authorship; or unusual courage and competency in an emergency.

## *Jay C. Quast Is Named NMFS Scientific Editor*

Jay C. Quast, a research scientist with the National Marine Fisheries Service's Auke Bay Laboratory in Alaska, has been named Scientific Editor of the NMFS Publications *Fishery Bulletin,* Special Scientific Report - Fisheries, and Circular. The Auke Bay Laboratory is a branch of the Northwest and Alaska Fisheries Center, Seattle, Wash.



Quast replaces Bruce B. Collette,

Assistant Director, Systematics Laboratory, National Marine Fisheries Service, at the U.S. National Museum in Washington, D.C. Collette had served as Scientific Editor for 3 years.

A graduate of the University of California, Berkeley, Quast received his Ph.D. degree in ichthyology from the University of California at Los Angeles in 1960. With the NMFS in Alaska since 1961, Quast has conducted and supervised research on the taxonomy, life history, population dynamics, and fisheries of demersal fishes. He also served for 2 years as Project Scientist for NOAA's Outer Continental Shelf Environmental Assessment Program. His scientific papers have won awards from the Auke Bay Laboratory and the American Fisheries Society.

Manuscripts to be considered for the *Fishery Bulletin,* SSR-F or Circular series should be addressed to: Dr. Jay C. Quast, Scientific Editor, Auke Bay Laboratory, Northwest and Alaska Fisheries Center, NMFS, NOAA, P.O. Box 155, Auke Bay, Alaska 99821.

## France, U.S. Agree on Ocean Programs

Joint scientific and technical cooperation in four areas of oceanography will be carried on by French and U.S. scientists over the next two years as a result of planning meetings held late last year in Bandol, France. Major projects approved at the meeting include a 2-year study of seafloor spreading in the Pacific, exchange of information in means of controlling oil pollution, marine environmental research, and research in diving medicine.

Head of the U.S. delegation was David H. Wallace, Acting Assistant Administrator for Fisheries of the Commerce Department's National Oceanic and Atmospheric Administration. The French delegation was led by Yves La Prairie, General Director of CNEXO (Centre National pour l'Exploitation des Oceans).

The East Pacific Rise at 21 degrees north latitude off the coast of Mexico will be the site of a major seafloor spreading study, to be carried out with the participation of Mexican scientists. The French submersible *Cyana* will be used in the area in 1978, and the U.S. Navy submersible *Alvin* from the Woods Hole Oceanographic Institution will be used in 1979. The East Pacific Rise in that area is a rapidly spreading undersea ridge connected with the extensive geologic fault system along the U.S. west coast. Scientists from France, Mexico, and the U.S. hope to learn more about the mechanism of seafloor spreading, formation of the earth's crust, and possible formation of metals.

The French and U.S. delegations agreed to hold demonstrations of oil pollution equipment each nation has developed, and made plans for a French expert to obtain training at the U.S. National Strike Force and, possibly, the Marine Environmental Protection School. France will sponsor a workshop in September 1978, looking toward multilateral exchange of information on oil spill cleanup information and techniques.

Marine environmental research—a new area of agreement within the cooperative program—will include an ongoing assessment of the environmental impacts of nuclear power plants, consideration of the use of bacteria for oil spill cleanup, and cooperative research on certain fish diseases.

Research in diving medicine will concentrate on determining ways that intravascular bubble detectors can be used to learn more about decompression and bubble formation. A transcutaneous bubble detector developed in France will be used to make a comparison of French and U.S. decompression tables. In addition, medical scientists of both nations will carry out cooperative studies of aseptic bone necrosis, a disease of bone tissue that sometimes may occur following exposure to compressed or rarified air.

### Tuna Regulations Issued for 1978

The number of porpoises that may be killed by U.S. tuna fishermen incidental to their fishing operations has been set at 51,945 in 1978, 41,610 in 1979, and 31,150 in 1980 under regulations published by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, a Commerce Department agency.

Other major changes to present regulations issued under the Marine Mammal Protection Act of 1972, require the yellowfin purse seine fishermen to install a porpoise apron system—a chute-like area in the back of the nets designed to permit porpoises to escape—in 1978.

Additionally, certificates of inclusion, under permits to engage in yellowfin purse seine fishing operations on porpoise, will be issued to both the vessels, through the vessel owners, and vessel operators rather than the vessel operators only, as is the current practice.

Rules have been established to allow amendments to the regulations and permits through informal rule-making during the 3-year period, rather than using a formal hearing by an Administrative Law Judge each year, unless major changes are proposed. In this event, a formal hearing may be required. The new regulations, which were effective 1 January 1978, are expected to achieve a 50 percent reduction in porpoise mortality by 1980 from the 1977 quota of 62,429. As of mid-November, approximately 24,500 porpoises had been killed in the fishery in 1977.

## Marine Education Agreement Signed

A cooperative agreement has been signed by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Office of Education to help develop a coordinated marine environmental education program at Federal, State, regional, and local levels. The pact, signed by NOAA Administrator Richard A. Frank and Commissioner of Education Ernest L. Boyer, establishes a formal relationship between the two agencies, sharing information to stimulate expansion of marine education.

NOAA, through its National Sea Grant Program, has supported marine education at all grade levels, from kindergarten through college. Because the Sea Grant Program is designed to support primarily local and regional programs, and most Sea Grant-supported institutions are in coastal areas, NOAA's marine education efforts have largely been limited to these areas.

Under the agreement, the Office of Education will encourage State departments of education, educational organizations, and colleges and universities across the Nation to work closely with existing marine-oriented institutions and programs. Special emphasis will be placed on Sea Grant projects dealing with the marine education of inner-city and minority children. This year about 10 percent of Sea Grant's $31 million budget was spent on marine education, representing an approximate 50 percent increase over last year.

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## NACOA Issues Annual Report, Asks for New Council to Develop and Coordinate Marine Strategy and Programs

Establishment of a Cabinet-level Marine Affairs Council in the White House to develop a national marine strategy and to coordinate Federal ocean programs has been recommended by the National Advisory Committee on Oceans and Atmosphere (NACOA).

The Advisory Committee, whose members are appointed by the President from outside the Federal Government, was created by the Congress in 1971 to report to the President and the Congress annually on the state of the Nation's marine and atmospheric programs. Its sixth annual report, prepared under the chairmanship of William J. Hargis, Jr., Director of the Virginia Institute of Marine Sciences, was transmitted to the President and the Congress on 28 September by Secretary of Commerce Juanita M. Kreps, together with comments reflecting the views of the various Federal departments and agencies.

In her comments, Secretary Kreps recognized the necessity for dealing effectively with the questions of a Marine Affairs Council being established and coordination of Federal ocean programs. She would, she said, ensure they are included in a major oceans policy review being undertaken by the Department of Commerce.

NACOA repeated its previous appeals for greater consolidation of Federal agency marine and atmospheric programs, but emphasized that the serious threat to the many uses of the sea posed by recent international developments calls for concerted action at the highest levels of government.

The report, citing the continued failure of the United Nations Conference on Law of the Sea to reach agreement on matters vital to the United States, increasing U.S. dependence on Middle East oil and on reliable shipping to transport it, and sharpening competition for ocean use and resource development, expressed concern "that we are ill-prepared to meet this challenge . . . because effective mechanisms do not exist either to develop an overall national strategy or to assure satisfactory agency performance and coordination in its execution."

The Committee urged accelerated exploration and development of offshore oil and gas, expediting marine solar energy systems development, and new legislation to provide a reasonable investment climate for U.S. industry to move ahead with development and production of deep seabed minerals.

It also recommended amendment of the Merchant Marine Act to update and clarify both commercial and national security goals for the U.S. merchant marine and amendment of the Marine Mammals Protection Act to remove inconsistencies and ambiguities hampering efforts to regulate the killing of marine mammals.

It cited the Fishery Conservation and Management Act of 1976 extending U.S. jurisdiction over fisheries out to 200 miles off the coasts as a model for responsible U.S. action in the face of lack of progress in the U.N. Law of the Sea negotiations, and commended the executive branch for its rapid and skillful implementation of the Act.

In the atmospheric area, NACOA called for the establishment of an Office of Measurement Science reporting directly to the Administrator of EPA to upgrade both the quality and usefulness of air pollution monitoring data collected by a heterogeneous set of networks throughout the Nation.

Additionally it urged accelerated action by the National Weather Service and the Defense Civil Preparedness Agency to complete current programs to improve emergency weather warning operations, increased emphasis on long-range weather forecasting technique development, and OMB action to release the new billets required to carry out National Weather Service obligations to provide reimbursable services to other Federal agencies.

It also reported progress towards goals previously recommended by NACOA in the areas of aquaculture, weather modification research, climate program development, coastal zone management and the preservation of the technologically advanced ship, the *Glomar Explorer,* pending the fuither evolution of projects now in early stages that would benefit from access to its capabilities.

**"A Report to the President and the Congress"** by the National Advisory Committee on Oceans and Atmosphere, Sixth Annual Report, 30 June 1977, is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

# Canada Reports Smooth, Effective Fishing Zone Control

"A very smooth operation and remarkably effective" is how Canadian Fisheries Minister Roméo LeBlanc summed up the first 8 months of Canada's management of the 200-mile offshore fishing zone. The extended zone, which took effect on 1 January 1977, gave Canada an area of more than 600,000 square miles of high seas to patrol and manage.

"We are proving to the world that we have the know-how and the equipment to efficiently manage this vast new area" said LeBlanc. "This isn't a miracle overnight cure for the fisheries, but a long-term plan to build up depleted stocks and develop a new era of prosperity for Canadian fishermen".

"As far as the East Coast stocks are concerned, we are applying strict conservation measures to make sure we do not replace foreign overfishing with Canadian overfishing. We see 1977 as the bottom of the trough for the groundfish catch. With good management it should be possible within 10 years to restore groundfish stocks to their full potential with an annual yield of about 1.6 million metric tons, which is more than double the 1977 TAC (total allowable catch)."

LeBlanc said that foreign fishing fleets have been virtually eliminated from a number of fisheries from which they formerly harvested a substantial portion of the allowable catch. Examples are cod, haddock, pollock, and herring on the Scotian shelf, American plaice and yellowtail flounder on the Grand Bank, and flounders generally on the Scotian shelf. There have also been substantial reductions in the foreign allocations of cod, redfish, and flatfish off Newfoundland-Labrador and an associated increase in the Canadian shares for these species.

Foreign fleets off Canada's East Coast in 1977 will harvest the bulk of the allowable catches of capelin, roundnose grenadier, silver hake, argentines, and squid. All of these are species for which so far it has been uneconomical for Canadians to develop a major fishery. By 1978, the foreign fleets will be largely out of the redfish fishery within the Canadian zone and will have smaller allocations of cod and flounder.

"Within the next 5 years, foreign fishing within our zone will likely be restricted to such species as capelin, grenadiers, argentines, and silver hake, and perhaps some portion of the northern winter cod fishery off northeast Newfoundland-Labrador", the Minister added. "Even for these species and stocks, the foreign share will be significantly decreased as the Canadian capacity to harvest and utilize these species is increased."

In order to manage the fish stocks within the 200-mile zone, the Fisheries and Marine Service has taken steps to substantially bolster its research capability. During 1977, 102 man-years will be added to the marine fisheries research staff, and an additional $4-6 million will be spent on fisheries research. This represents a doubling of the Service's resource assessment activities in the offshore area. Plans are also in hand for the chartering and construction of new research vessels.

As a condition of licensing, foreign fishing vessels must supply the Canadian authorities with information on catch and fishing effort. In addition, Canada is placing scientific observers on selected foreign fishing vessels to collect biological data and to obtain more detailed information on bycatches and discards. A number of cooperative research survey experiments involving the use of foreign research vessels have also been initiated. Two of these involve mesh selection experiments with USSR and Cuban research vessels on the Scotian shelf, which should provide better information on the effects of mesh size on bycatch of other species in the directed silver hake fishery.

Playing a vital role in the management of the 200-mile zone is the computerized database system known as FLASH (Foreign Fishing Vessels Licensing and Surveillance Hierarchical Information System). The system keeps track of the foreign vessels operating within the zone and provides up-to-the-minute information on fish catches, quotas, etc.

Developed within the Fisheries and Marine Service, the FLASH system has generated considerable international interest. Visitors from Iceland, Australia, New Zealand, Japan and the United States have seen the system at work. Some countries have expressed strong interest in developing a similar system for their own extension of fisheries jurisdiction.

## *FLASH: Enforcing Canada's 200-Mile Zone*

Along with the 200-mile limit on 1 January 1977, Canada introduced a comprehensive enforcement plan including a computer information bank

on foreign fleet activities, Environment Canada reports.

The computer helps keep track of a dwindling foreign fleet. In 1975, there were 1,500 or more foreign vessels fishing off Canada's coasts. In 1977, there were less than 500 fishing vessels (Table 1), many staying for shorter periods. There will be fewer again this year. These vessels can fish only as specified on the license issued by Canada, spelling out fishing periods, areas, methods, catch regulations, and so on.

The Department of Fisheries and the Environment has eight offshore patrol vessels on the Atlantic coast, three on the Pacific, where the coast is shorter and the fishing banks narrower. In 1977, from the 12 Department of National Defence destroyers on the Atlantic coast, the fisheries department was to get 230 days of fisheries patrol, and from the four on the Pacific coast, 183 days. The fisheries department's own fleet of 11 offshore patrol vessels provides about 1,500 days, and there are about 240 patrol days by Coast Guard vessels, including a large number of icebreaker patrols to police winter fishing to northern areas. Helping guide the combined fleet towards any violators are the air patrols, 4,200 hours (in 1977) by DND Trackers, which once or more every week inspect every key fishing bank and fishing boundary (Table 2). The long-range Argus aircraft also carry out fisheries surveillance along with other work.

Into the computer network, called FLASH, go sightings, catch reports, and requests for entrance into the Canadian zone. The computer contains the details of every foreign fishing licence, what each vessel can fish for, where, when, and with what gear. The computer provides reports to St. John's, Halifax, and Vancouver on fleet activities, percentage of quota caught, and other information to help guide surveillance activities.

About 1,000 at-sea and in-port inspections of foreign vessels were expected in 1977. Maximum fines on a single charge are $25,000; other possible penalties are loss of catch, vessel, and fishing licence. Jail sentences can go up to 2 years. Given sufficient justification, Canada could also take away the licences of all other vessels from the offender's country.

Up to 31 August 1977, there were nine arrests that resulted in court-imposed fines (Table 3), and a number of warnings and administrative actions such as licence cancellations and refusals. On several occasions, the surveillance authorities caught vessels during their first day of attempted fishing in an illegal area. Besides policing the Canadian zone, Canada retains participation in the mutual enforcement scheme of ICNAF (the International Commission for the Northwest Atlantic Fisheries); this lets Canadian inspectors board vessels outside the 200-mile zone subject to ICNAF regulations.

**Table 1.—Foreign fishing vessels licensed by Canada 1 January to 15 August 1977.**

| | Type of vessel | | | |
|---|---|---|---|---|
| Country | Support | Research | Fishing | Total |
| Atlantic | | | | |
| Bulgaria | 2 | | 7 | 9 |
| Cuba | 4 | 1 | 8 | 13 |
| Denmark | 0 | | 34 | 34 |
| Fed. Rep. Germany | 1 | 1 | 19 | 21 |
| France | 0 | 1 | 20 | 21 |
| German Dem. Rep. | 1 | 1 | 14 | 16 |
| Iceland | 0 | | 2 | 2 |
| Italy | 0 | | 6 | 6 |
| Japan | 11 | | 14 | 25 |
| Norway | 0 | | 44 | 44 |
| Poland | 14 | | 18 | 32 |
| Portugal | 0 | | 45 | 45 |
| Romania | 2 | | 4 | 6 |
| Spain | 0 | | 86 | 86 |
| United Kingdom | 0 | | 10 | 10 |
| USSR | 84 | 3 | 101 | 188 |
| Total | 119 | 7 | 432 | 558 |
| Pacific | | | | |
| Japan | 21 | | 31 | 52 |
| Poland | 0 | | 6 | 6 |
| S. Korea | 0 | | 1 | 1 |
| USSR | 7 | | 7 | 14 |
| Total | 28 | | 45 | 73 |

**Table 2.—Canadian surveillance of foreign fishing vessels, 1 January to 15 August 1977.**

| Atlantic inspections | At sea[1] | In port | ICNAF area | Total |
|---|---|---|---|---|
| Bulgaria | 8 | 10 | — | 18 |
| Canada | 106 | 2 | 4 | 112 |
| Cuba | 24 | 4 | — | 28 |
| Denmark | 2 | 1 | 2 | 5 |
| France | 26 | 1 | 3 | 30 |
| Germany (FRG) | 7 | 5 | — | 12 |
| Germany (GDR) | 6 | 1 | — | 7 |
| Italy | 6 | 1 | — | 7 |
| Japan | 9 | 6 | — | 15 |
| Norway | 3 | 6 | — | 9 |
| Poland | 6 | 15 | — | 21 |
| Portugal | 14 | 35 | 14 | 63 |
| Romania | 2 | 1 | — | 3 |
| Spain | 43 | 21 | 4 | 68 |
| U. K. | 8 | 5 | 2 | 15 |
| USSR | 154 | 57 | 17 | 228 |
| USA | 5 | 1 | — | 6 |
| Nigeria | — | 1 | — | 1 |
| Total | 429 | 173 | 46 | 648 |

Ship days

| | | | |
|---|---|---|---|
| DFE ships | 578 Sea days | Flying hours | 2,266 Hours |
| DND ships | 209 Sea days | Air patrols | 354 Tracker |
| DOT ships | 250 Sea days | | 39 Argus |
| Total | 1,037 Sea days | | |

| Pacific inspections | |
|---|---|
| Japan | 50 |

Ship days

| | | | |
|---|---|---|---|
| DFE ships | 285 Sea days | Flying hours | 643.1 Tracker |
| DND ships | 36 Sea days | | 218 Argus |
| Total | 321 Sea days | | 861 hours |

[1]Inside 200-mile zone.

**Table 3.—Violations in Canadian fisheries waters, 1 January-31 August 1977. This table includes only court convictions for infractions within the Canadian zone. Surveillance authorities have also issued several warnings for borderline offences, and have taken administrative actions such as cancelling licences; in other instances, court action is pending. Besides the surveillance checks within the Canadian zone, Canadian authorities have also detected several violations of ICNAF regulations by vessels outside the Canadian Atlantic zone within the ICNAF area. Reports of such violations go to the home country for punitive action through ICNAF.**

| Vessel | Country | Date | Violations | Measures taken |
|---|---|---|---|---|
| *Bergbjorn* | Norway | 2/17 | Fishing in Canadian zone without licence. Entering zone without 24-hour notice. | Captain convicted, fined $5,000, licence refused. |
| *Groenland* | France | 3/30 | Fishing with undersized mesh. | Captain convicted, fined $1,000, net seized. |
| *Ritsa* | USSR | 4/18 | Fishing without a licence. | Detected on first day, captain convicted, fined $2,500. |
| *Goelette* | France (St. Pierre) | 5/12 | Illegal mesh size and illegal chafing gear. | Captain convicted, fined $1,500 ($750 each charge), net seized. |
| *Kara Kuny* | USSR | 5/22 | Fishing in unlicensed area. | Captain convicted, fined $3,500. |
| *Nikolay Papuin* | USSR | 5/22 | Fishing in unlicensed area. | Captain convicted, fined $3,500. |
| *Auriga* | Poland | 5/29 | Undersized nets. | Captain convicted, fined $1,000. |
| *Navagante* | Portugal | 6/19 | Fishing after licence had expired. | Captain convicted, fined $500. |
| *Petrok-repost* | USSR | 5/22 | Fishing without a licence (two incidents). | Captain convicted, fined $8,000. |

## New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents (address given at end of title paragraph on pertinent publications) or from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Writing to the agency prior to ordering is advisable to determine availability and price where appropriate. Prices may change and prepayment is required.

NOAA Technical Report NMFS SSRF-711. Rice, Dale W. **"A list of the marine mammals of the world."** April 1977. 15 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

Listed are the 116 species of Recent marine mammals, including freshwater species of the predominantly marine groups. The number of species are: Order Carnivora, 36 (polar bear, sea otter, and 34 pinnipeds); Order Sirenia, 5; Order Mysticeti, 10; and Order Odontoceti, 65. The geographic distribution of each species is indicated.

NOAA Technical Report NMFS SSRF-712. Bruce, Herbert E., Douglas R. McLain, and Bruce L. Wing. **"Annual physical and chemical oceanographic cycles of Auke Bay, southeastern Alaska."** May 1977. 11 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

The annual cycles of physical and chemical oceanographic conditions in Auke Bay, a small estuary in southeastern Alaska, showed a consistent pattern over an 8-year period (1961-68). The cycles closely followed seasonal climatological and atmospheric events. Increased insolation in the spring caused general warming of the surface water and the air, which in turn increased the freshwater input into Auke Bay from melting snow and ice. The fresh water lowered surface salinities and together with warming of the surface waters caused a density stratification of the water column, which increased as the spring-summer season progressed. Maximum stratification occurred in August, followed by a general decay of stratification in September. Vertical mixing of the top 20 m of the water column by fall storms in September and cooling of surface water resulting from decreased insolation set up a thermohaline circulation that continued through the fall and early winter. The water column became homogeneous by January and remained thoroughly mixed from January through March or early April. Auke Bay was rich in the inorganic nutrients phosphate, silicate, and nitrate. Spring phytoplankton blooms followed the onset of stratification and drastically reduced the concentration of all three nutrients in the surface water. Nitrate was essentially depleted and remained so throughout the summer. Low nitrate availability was undoubtedly one of the important factors limiting primary production in Auke Bay.

NOAA Technical Report NMFS Circular 403. Cutler, Edward B. **"Marine flora and fauna of the northeastern United States. Sipuncula."** July 1977. 7 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

This report includes an account of the five species of Sipuncula living in shallow waters (down to 200 m) from Maine to Virginia. Four of these are widespread elsewhere in the world—*Golfingiaeremita, G. margaritacea, G. minuta,* and *Phascolion strombi. Phascolopsis gouldi* is endemic to the east coast of North America. An introduction to their biology, an annotated systematic list, selected bibliography, and an illustrated key are presented.

## ICES Issues Statistics, Studies on Fish Stocks

The International Council for the Exploration of the Sea (ICES) issued in April 1977 the **"Annales Biologiques-1975,"** containing yearly records and data, arranged by species and areas, of the state of fishery and shellfish stocks in the northeast Atlantic. The Council, located in Charlottenlund Slot, Denmark, has served as a scientific advisory body for the Northeast Atlantic Fisheries Commission (NEAFC) specializing in marine biological research, especially stock assessment.

The present volume is a 214-page collection of 113 contributions, organized in three parts, dealing with 1) hydrography, 2) plankton, and 3) the major fish species. The longest part is devoted to fish, and this section is divided according to the major groups of fish species, the most important being the Gadoids (cod-like fishes) and the Clupeoids (herring-like fishes). Practically all of the studies deal with the state of fishery stocks in 1974 and 1975 and are therefore somewhat dated. In addition, the data tend to be most complete in those studies which focus on the North Sea, although there is a wealth of information on the entire area falling under ICES jurisdiction. There is also a preface by the Director of ICES, Hans Tambs-Lyche, and a short section reporting the results of joint fishery research projects undertaken in 1975.

Those interested in obtaining a copy

of the "Annales Biologiques" (cost is about $14) should write to: International Council for the Exploration of the Sea, Charlottenlund Castle, DK-2920 Charlottenlund, Denmark.

## U.S.-Foreign Fisheries Report Printed by GAO

The General Accounting Office has prepared a 477 page report for the Congress entitled **"The U.S. Fishing Industry—Present Conditions and Future of Marine Fisheries."** In addition to analyzing Federal fishery laws, summarizing basic data on major U.S. fisheries, detailing domestic and foreign catches off the U.S. coasts, and assessing the impact of the U.S. 200-mile zone on international fishery conventions and agreements, the report has profiles of the fishing industries of Canada, Denmark, Japan, Mexico, the Soviet Union, the United Kingdom, and the Federal Republic of Germany. These foreign fishery reports were primarily based on material obtained from the files of the NMFS Branch of International Fishery Analysis.

A copy of the report may be purchased for $1.00 by requesting report CED-76-130-A, 23 December 1976, from: U.S. General Accounting Office, Distribution Section, P.O. Box 1020, Washington, DC 20013. Payment should be made by a check payable to the U.S. General Accounting Office.

## BEAUFORT SEA FISH BIBLIOGRAPHY NOTED

A new bibliography on fish resources of far-northern waters has been published by the University of Alaska. The publication, **"An Annotated Bibliography of the Fishes of the Beaufort Sea and Adjacent Regions,"** was compiled by Wilma E. Pfeifer of the Institute of Arctic Biology.

"This bibliography was prepared to serve as a reference base for further studies in the area, particularly as related to the impact of petroleum exploratory activities on the fish fauna," writes Pfeifer in the introduction. "Included are all discovered references on the fishes of the Beaufort Sea and/or immediately adjacent regions."

Preparation of the bibliography was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, which is charged with conducting environmental assessment work on the Outer Continental Shelf in connection with planned offshore petroleum development. Inquiries concerning the publication should be addressed to The Editor, Biological Papers of the University of Alaska, Fairbanks, Alaska 99701.

## "Industrial Fishery Technology" Revised

A second edition of the book, **Industrial Fishery Technology,** edited by Maurice E. Stansby, has been published. Chapters have been updated, and in some cases extensively rewritten. Two new chapters have been added. One of these, by Maynard Steinberg and John Spinelli, is entitled, "Some Developing Trends for the Use of Fishery Resources." The other, by Maurice Stansby and Richard Nelson, is titled "Contaminants and Pollution."

As with the first edition, the book limits coverage to practices and applications in the United States. The 29 chapters, written by various fisheries specialists in the different fields, are grouped into five categories: 1) Fishes and Fishery Methods; 2) Description of Important Fisheries and Their Products; 3) Fishery Industrial Products; 4) Preservation Methods; and 5) Food Science Applications.

The new edition is published by Robert E. Krieger Publishing Co., Inc., Huntington, NY 11743, and is priced at $18.50.

## *Fishery Economics Volume Published*

Publication of Lee G. Anderson's **"The Economics of Fisheries Management,"** for Resources for the Future, Inc., has been announced by the Johns Hopkins University Press, Baltimore, Md. The author has aimed this concise treatment of fisheries economics mainly at the noneconomist.

The first chapter introduces basic economic concepts while Chapter 2 treats fundamentals of fisheries economics. The main economic analysis is spelled out in Chapter 3, "A More Complete Analysis of Fisheries Economics."

Chapter 4, "Refinements of the Analysis," introduces more complex assumptions and gets into the more intricate economic models of fishery exploitation. Chapter 5 discusses fishery regulations, focusing on their economic aspects. Then, the U.S. northern lobster fishery and British Columbia's institution of a limited-entry system are used in Chapter 6, "Practical Applications," to show how the theory of the previous chapters can be used to provide useful information.

The 214-page hardbound book includes a list of "Study Questions" for chapters 2-5 and an index. It costs $14.00.

## *Torry Research Unit Issues Annual Report*

The Torry Research Station, a subdivision of the U.K. Ministry of Agriculture, Fisheries, and Food specializing in fisheries technology research, has issued its 1976 annual report. The 36-page report consists of 26 sections, usually only a page or two long, devoted to some special area of utilization, processing and product research, and an appendix which provides a thorough organizational breakdown of the various research groups, including the names of senior scientists and the cost of the programs.

In the introductory remarks, the Director of the Torry Research Station, G.H.O. Burgess, explains some of the broader considerations which determine the current focus and direction of U.K. efforts in fisheries technology research. With the decline of Britain's distant-water catch, due to exclusions and reductions of fishing around Iceland and off Norway, the U.K. fishing

industry must find substitutes for such traditionally favored species as cod and haddock, and must depend more heavily on fish caught within its 200-mile zone. This explains the high priority given to projects dealing with blue whiting, crab, Norway lobster (scampi), squid, krill, and new species for reduction to fish meal. The emphasis is on finding species and processed products which will be acceptable to British consumers and to the poultry and livestock industry.

Although there are several encouraging prospects, it appears from Burgess' introduction and the text that the most promising project is the research on the processing of blue whiting. He is optimistic enough to predict that the necessary technology will be developed by 1978 or 1979 to utilize blue whiting on a fairly wide scale as a food fish. The Torry Research Station, in Aberdeen, Scotland, had a 1976 staff complement of about 90 professionals and 130 nonprofessionals, and an operating budget of $2.7 million. The Station also has one research trawler and a mobile laboratory. Those interested in receiving a copy of the report should write to: Torry Research Station, P.O. Box 31, 135 Abbey Road, Aberdeen, Scotland, AB9 8DG, United Kingdom. (Source: IFR-77/155.)

## Japan Marine Product Import Groups Listed

A list of the members of the Japan Marine Products Importers Association has been submitted by the U.S. Regional Fisheries Attache in Tokyo. The listing is alphabetical, followed by an addenda, and includes each company's name, address, telephone and telex numbers, as well as the commodities in which the companies specialize.

The list is available from NMFS Regional Statistics and Market News Offices by requesting a copy of IFR-77/154 and enclosing a self-addressed mailing label.

## Foreign Fisheries Volumes Translated

Copies of the following books, recently translated for the National Marine Fisheries Service under the Special Foreign Currency Science Information Program, are available from the Language Services Branch, F412, Office of International Fisheries, National Marine Fisheries Service, NOAA, Washington, DC 20235. Please request by accession (TT) number.

The volumes are: TT 76-5001, "Selected Works on Fishing Gear" by F. I. Baranov; TT 76-5002, "Handbook of Hydrological Studies in Oceans and Seas" by I. M. Soskin; TT 76-5005, "Camallanata of Animals and Man and Diseases Caused by Them" by V. M. Ivashkin et al.; and TT 76-5008, "Forecasting of Hail, Thunderstorms and Showers" by G. K. Sulakvelidze et al.

## *FRG Fisheries Research Agency Reports for 1976*

The Federal Fisheries Research Agency (Bundesforschungsanstalt für Fischerei) in Hamburg, a division of the Ministry for Food, Agriculture, and Forestry in the Federal Republic of Germany (FRG), has issued its 1976 annual report. The 76-page report, in German, provides a detailed and thorough account of research activities, personnel, and cooperation with other FRG and foreign government agencies. The Agency, directed by Dietrich Sahrhage, employs 214 persons (of which 68 are scientists) in four research institutes and an isotope laboratory.

The major efforts in 1976 were in the fields of stock assessment, research on new and underutilized species, and scientific cooperation with several international organizations responsible for fishery affairs, such as NEAFC, ICES, and ICNAF. The most publicized FRG fishery research projects were those undertaken by the group specializing in distant-water fisheries with the research vessels *Walther Herwig*, *Anton Dohrn*, and *Solea*. The results of their studies, including research on krill in the Antarctic, blue whiting in the northeast Atlantic, and several other species, will be of considerable interest to marine biologists and those concerned with the policy and commercial aspects of international fisheries. Other sections of the report discuss the work of the Fisheries Research Agency in the areas of coastal fisheries, new catch techniques, and recent developments in fisheries biology and marine pollution. Those interested in obtaining a copy of the report should write to: Professor Dietrich Sahrhage, Director, Bundesforschungsanstalt für Fischerei, Palmaille 9,2000 Hamburg 50, Federal Republic of Germany. (Source: IFR-77/172.)

## "Practical Shellfish Farming" Published

Publication of **"Practical Shellfish Farming"** by Phil Schwind has been announced by International Marine Publishing Company, 21 Elm Street, Camden, ME 04843. Schwind, who has authored "Making a Living Alongshore," "Clam Shack Cookery," and "Cape Cod Fisherman," is a long-time commercial fisherman who teaches a course on aquaculture at a local community college. Also Shellfish Constable for the Cape Cod town of Eastham, Mass., the author gives a brief history of shellfish farming in that area, describes shellfish farming experiences on Cape Cod, where, he says, their shellfisheries have increased tenfold.

Short chapters discuss the author's experiences in farming quahogs, *Mercenaria mercenaria*, clams, *Mya arenaria*, oysters, *Crassostrea virginica*, and blue mussels, *Mytilus edulis*.

Schwind discusses selecting an area and getting the appropriate grant to farm it, acquisition of seed, planting methods, shellfish growth, types of culture (off-bottom, bottom culture, rope culture, trays). One chapter is devoted to Predators and Their Control. The 91-page hardbound book also includes a short glossary and bibliography. It costs $8.95.

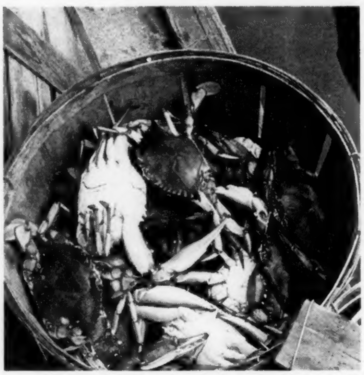
# Of Squid, Tarpon, Blue Crab, and King Salmon

. . . . **During the first 9 months of enforcing the new 200-mile Fisheries Conservation Zone,** the United States Coast Guard reports boarding 1,914 vessels. Some 419 were cited for violations, 221 civil penalties were issued, and three foreign ships were seized as was part of the cargo of a fourth. Fines imposed upon the three seized vessels totaled $589,900. In search and rescue operations during 1977, the Coast Guard responded to more than 71,000 calls for help, and provided rescue assistance estimated to have saved several thousand lives and more than $2.8 billion worth of property. . . .

. . . . The Alaska Board of Fisheries reports adopting **regulations to permit king salmon, *Oncorhynchus tshawytscha,* fishing opportunities in Cook Inlet waters** for both sport and commercial fishermen. Eight upper Cook Inlet streams are to be reopened to recreational king salmon angling and a limited commercial set net test fishery will be opened in June. No fishing had been allowed for king salmon in the Susitna River system's eight streams since 1972, and the board noted that stocks have begun to show signs of recovery. . . .

. . . . Meanwhile, the Alaska Board of Fisheries adopted a policy for the **long-term management of Cook Inlet salmon stocks,** as competition between the various user groups for Cook Inlet salmon grows. The policy, according to Board Chairman Nick Szabo, Kodiak, Alaska, is not to establish exclusive uses of salmon stocks, but to define and identify the primary beneficial uses of the stocks. Their ultimate goal, said Szabo, is salmon protection and, where feasible, rehabilitation and enhancement. One of the purposes of the policy is to provide long-term goals so both sport and commercial users may make plans consistent with those goals. . . .

. . . .**With interest growing in the blue crab, a prime Texas commercial** saltwater species, that state's Parks and Wildlife Department has launched a new study of the species. Disastrous blizzards along the nation's eastern seaboard last winter reportedly drove a number of professional crab fishermen to Texas. That influx, coupled with generally higher seafood prices, stimulated crabbing to an unprecedented high level in 1977 and the year's catch was expected to set an all-time record. By the end of October, landings had totaled 7,056,000 pounds, surpassing the 1973 high of 6,881,000 pounds. In the study's first step, an aerial count of crab traps in October showed 7,000. An estimated 140 full-time and 150 part-time crab fishermen were operating along Texas' coast last fall. . . .



Blue crabs, *Callinectes sapidus.*

. . . . **A survey of anadromous fish spawning streams in the Chesapeake Bay area** north of the Bay Bridges has shown 447 man-made blockages on 401 inventoried streams, the Maryland Department of Natural Resources reports. The blockages include dams and weirs ranging in height from one foot up to the size of large dams like Conowingo, Lock Raven and Liberty. Most of the structures, the survey shows, are from 3 to 6 feet high and are of earthen construction. The survey, during which every stream in the area was "walked" by investigators, took 6 years, and when completed will show the amount of anadromous fish spawning grounds lost because of the blockages. Affected species include shad, herring, yellow perch, and white perch. . . .

. . . . **An experimental Russian trawler, the *Argus,* failed to find** commercial quantities of squid off the southeastern U.S. coast during a 2-day exploratory fishing cruise late last year, the South Carolina Wildlife and Marine Resources Department reports. However, the Russians did find just enough squid to encourage them to look again early in 1978 if allowed to do so. With a crew of 74, including 11 scientists and several interpreters, the *Argus* had been doing exploratory fishing with other American observers out of Woods Hole, Mass., and was reportedly on its way to Havana for the winter. . . .

. . . .**Tarpon may be staging a comeback in Texas waters according to** Parks and Wildlife Department fishery biologists. Several 30-inch specimens taken there apparently as a result of a rare tarpon spawning in the fall of 1975 in Galveston Bay. The tarpon were believed to have hatched in the shallow Gulf during the summer of 1975 when a large number of that species was spotted off the upper Texas coast. The tarpon remained in the Houston Ship Channel throughout the winter and spring of 1976 near the Pasadena Deep Water Power Plant thermal discharge where water temperature was 10-16° warmer than average Galveston Bay temperatures. The fish have now been taken in Lake Sabine, Matagorda Bay, and Aransas Bay . . . .

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